Materials & Methods

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NEXT MONTH: How Materials Development Improved Performance . . . Magnetic Oxides as Magnetic Materials . . . Hardening Enhances Properties of Malleable Iron . . . Scrap Aluminum for Die Castings . . . Nonslip Materials . . . Induction Annealing of Light Steel Stampings . . . Manual Submerged Arc Welding . . . COLORING OF METALS (Materials & Methods Manual No. 50)

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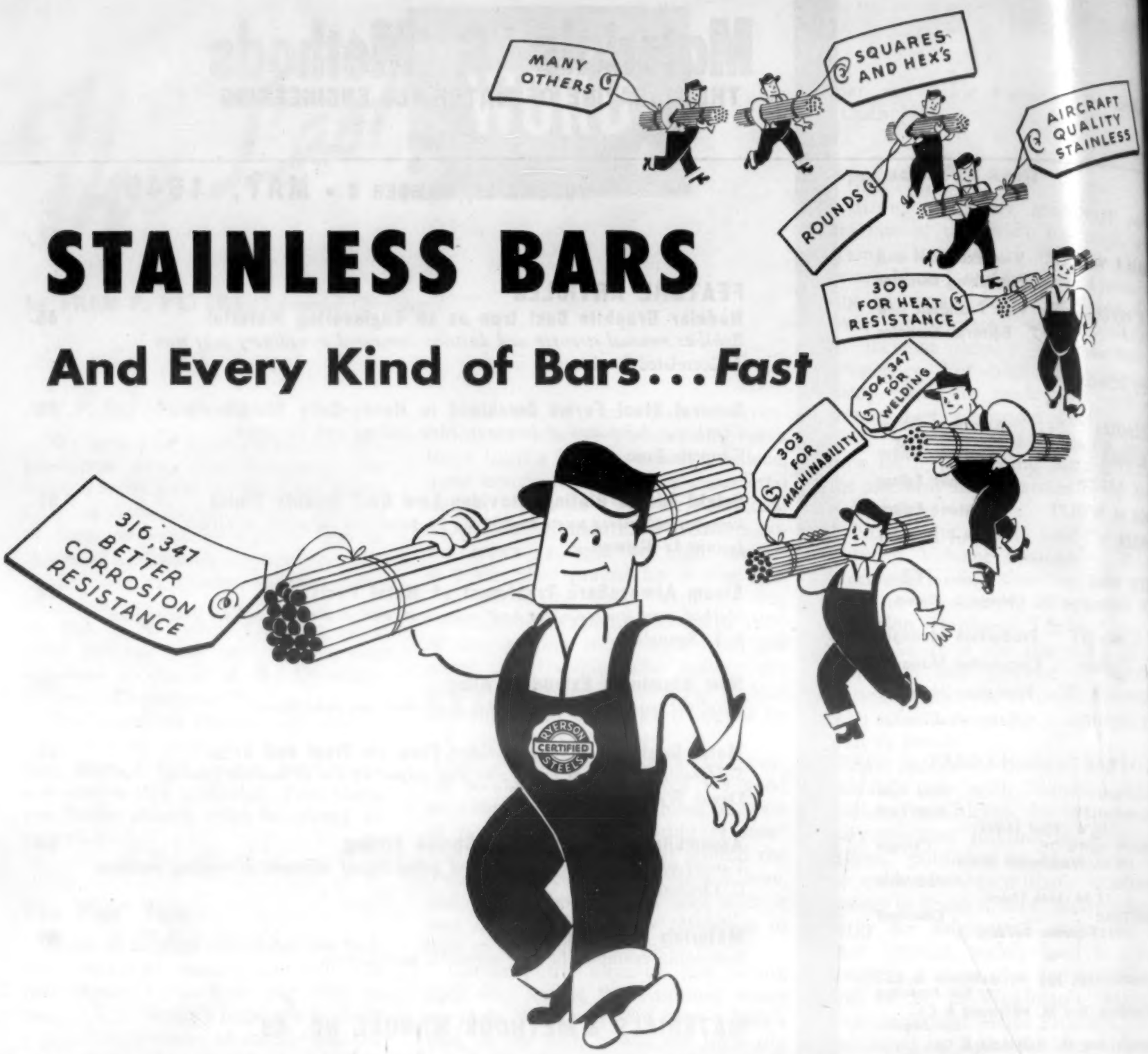

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EDITORIAL

Needed: Better Materials Engineering

It is impossible to estimate with any degree of accuracy, but it is safe to say that poor materials selection costs this country millions of dollars each year. Much of this economic waste could be eliminated with an additional savings in time and worry.

From our point of view, there are two basic faults which lead to poor materials selections and applications. First, many materials choices are made by persons who should but don't understand the basis for selecting a material for a given application. Many choices are made after consultation with a table of characteristics, but without any understanding of what the values given there mean and without interpreting them in light of the proposed application.

Second, many special compositions are specified for applications where standard compositions would be more than adequate. Almost in the same category is ordering to strict chemical specifications when it is a definite hardenability value which is desired.

Numerous examples of both situations come to mind readily, but one or two should be sufficient to bring home the point. Recently we were told about an application of cast magnesium. The magnesium castings were assembled in an agricultural implement. Many tests showed the application to be ideal. The magnesium saved considerable weight, had sufficient strength, and retained a sufficiently sharp edge to chop the freshly cut hay which passed through it.

Service reports were enthusiastic, for the first year. Then came reports that holes could be poked through the magnesium castings by the pressure of a single finger. Was the casting faulty? No. Does magnesium corrode too easily? No. What was the fault? It seems that the person or persons responsible for the choice overlooked entirely the fact that the magnesium casting would be in direct contact with a steel plate in a location which would be wet constantly. Naturally, a well working galvanic cell was created and it was only a matter of time until the magnesium was useless.

In this case, both the company making the product and the foundry which supplied the castings were at fault, since they worked cooperatively on the project. Before a solution could be worked out, the magnesium castings were thrown out as useless. In addition, replacements had to be made on all of the units sold. All in all, it was a tidy sum that was wasted, simply because the whole job was not considered.

The answer lies in handing materials problems to practical materials engineers. Their minds are trained to consider all aspects of a material's characteristics and how these characteristics are affected by service conditions. However, many companies will not even invest in the salary of one man to insure putting the right materials in the right place at the right time.

T. C. Du Mond
Editor

How To Cut Your Steel Requirements

25%

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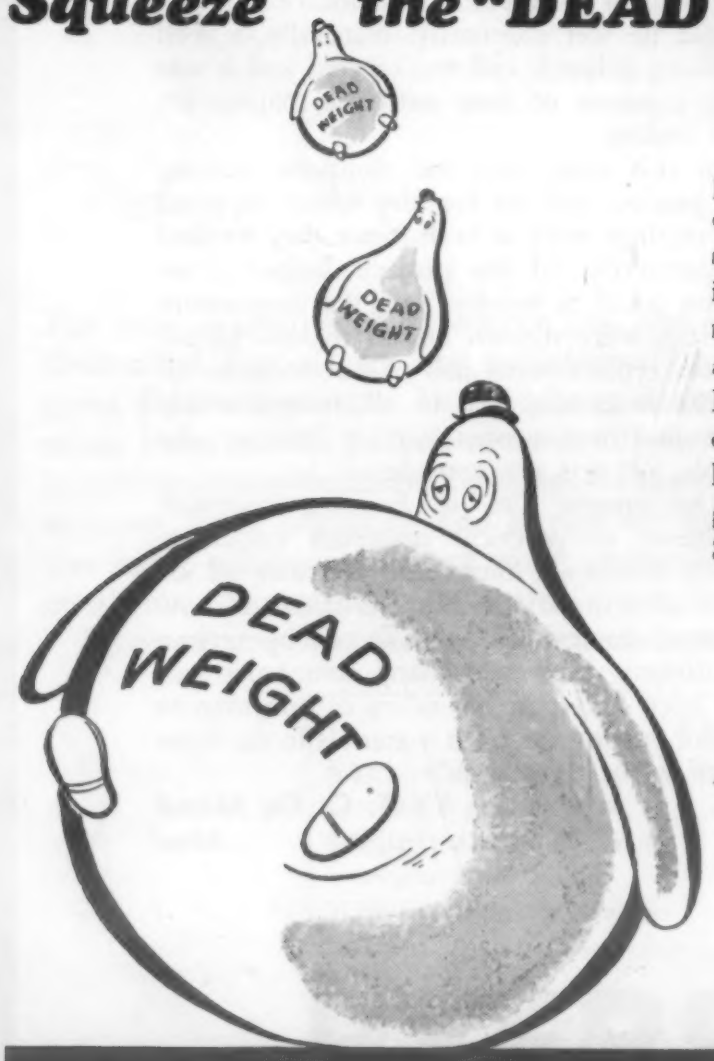

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THE LOW-ALLOY HIGH-STRENGTH STEEL

Materials & Methods
MAY 1949

Nodular Graphite Cast Iron as an Engineering Material

— A CORRELATED REVIEW

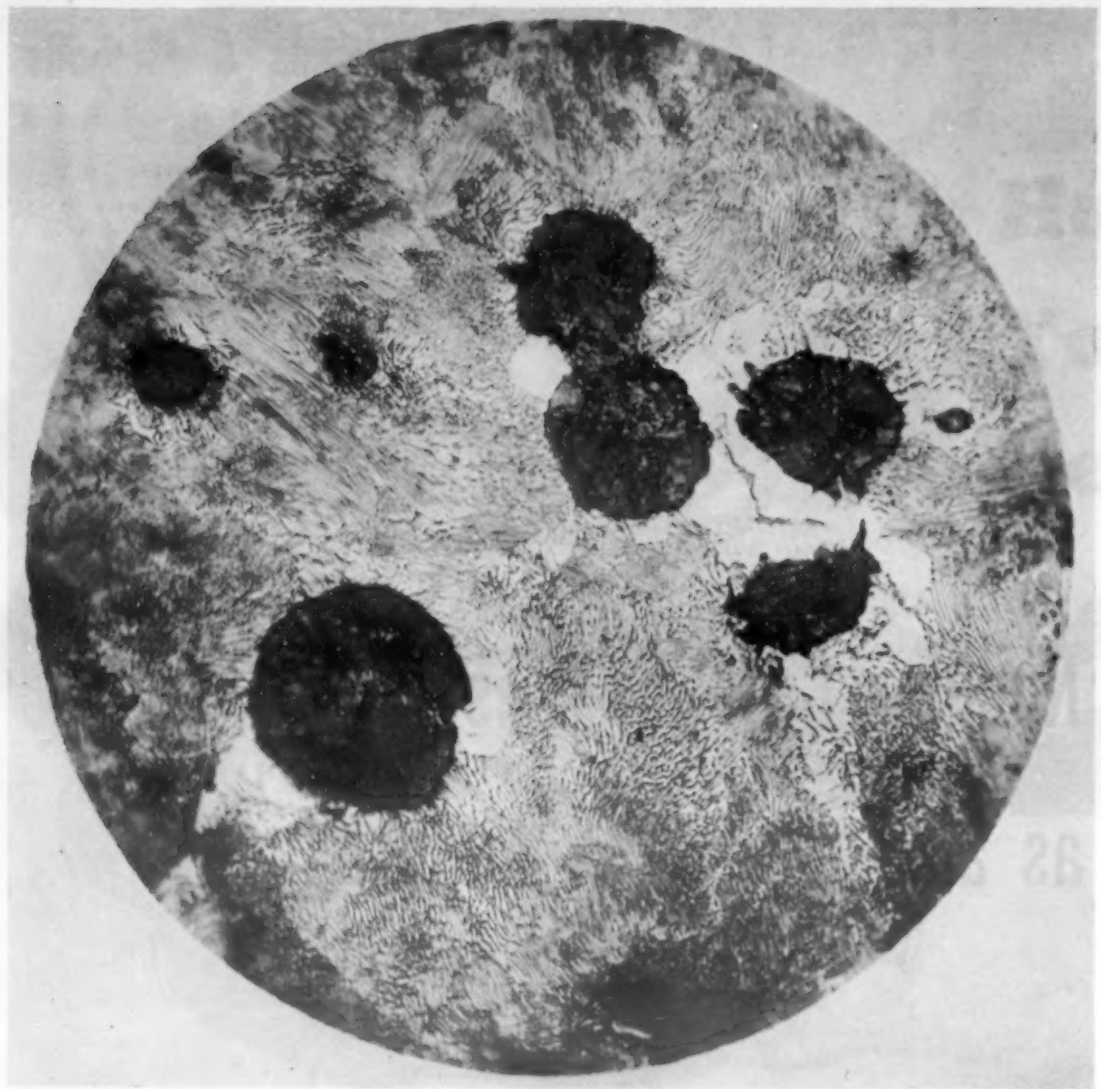
These new cast irons having graphite in a nodular rather than flake form exhibit unusual strength and ductility properties. Here is a comprehensive account of their characteristics, possible applications, and method of production.

• DURING THE PAST several years interest in the development of nodular graphite irons has been steadily mounting. The reason for the growing interest is that this development shows promise of providing a group of low-cost cast irons with greatly improved properties over gray iron and which may even become a strong competitor of malleable iron and cast steel. Nodular graphite cast irons are right now in the process of advancing from the laboratory and pilot plant stage into commercial production, and so the problem of finding suitable applications and uses lies directly ahead. The purpose of this article is to review the information now available on this new engineering material and thereby indicate where its potential uses might be.

As is well known, the properties of irons are significantly influenced by the presence, shape and distribution of graphite. The graphite in ordinary gray cast iron is in the form of thin flat flakes that are distributed through a matrix of pearlite and some ferrite. This flake graphite greatly limits the mechanical properties of gray cast iron and causes it to be relatively brittle and of low strength. In malleable iron, however, the graphite has a nodular shape and is distributed through a ferritic matrix. Malleable irons have relatively higher mechanical properties, one of the principal reasons being the presence of nodular graphite. Because of this, it has been generally accepted that if nodular graphite could be produced in gray iron, as cast, a considerable improvement in mechanical properties would result.

In the early twenties, Smalley in England reported on some experiments using small additions of magnesium, as well as tellurium and titanium, to obtain nodular graphite structures. However, these metals, including magnesium, were much too expensive at that time and additional work was required to make the process commercially applicable.

A long-term investigation by the British Cast Iron Research Assn. resulted in the announcement in 1947 of a method of achieving nodular graphite by the controlled treatment of molten iron with cerium. In this country, work by several companies, including American Cast Iron Pipe Co., International Nickel Co., Dow Chemical Co., and Meehanite Corp.,



Photomicrograph of nodular graphite cast iron shows spheroidal shape of graphite (750 X). (Courtesy Meehanite Metal Corp.)

has proceeded along somewhat different lines. They have experimented successfully with magnesium and magnesium alloy additions to the ladle to bring about a structure containing nodular graphite.

In principle, however, both approaches are the same. Briefly, the method involves the introduction of a relatively small addition of cerium or magnesium to the molten iron in the ladle shortly before casting. This addition converts part or all of the graphite to a spheroidal form. The differences between the methods of achieving this nodular graphite structure arise in the composition requirements of the base iron, and in the ease and cost of production.

The principal composition requirements of iron that is to be treated with cerium are that it must be a high carbon (hypereutectic), low sulfur, low phosphorus iron. Carbon should exceed about 3.5%; sulfur content must be below about 0.02%; phosphorus must not exceed about 0.6% and should be preferably below 0.1%.

The most economical form of the cerium addition at present is as mischmetal, which consists of 50% cerium and 50% of other rare earths. There are two different ways in which cerium is used. In one method, referred to as the "single treatment" by the British, a simple addition of cerium is made to the melt. This treatment does not produce a completely developed nodular graphite structure, but rather produces some graphite resembling flake graphite plus some graphite nodules. The other method, called the "double treatment," involves the addition of a graphitizing inoculant (a silicon-manganese-zirconium alloy) to the molten metal simultaneously with, or immediately after, the cerium addition. With this treatment it is possible to obtain completely nodular structures.

At present the cerium treatment is largely limited to use in England. However, considerable interest is being shown in the possible future use of cerium in this country, and a number of foundries are now experimenting with it. Contrary to some reports, cerium is quite freely available in this country for cast iron production.

One of the present drawbacks to the use of cerium is its cost, which ranges around $4.00 to $5.00 per lb. Thus, the cost of the cerium treatment runs somewhere around 1½¢ per lb., or between $25 and $30 per ton. Investigations are now under way to determine whether less costly combinations of cerium and other rare earths will satisfactorily produce nodular graphite structures.

The magnesium treatment can be used over a wider range of iron compositions than cerium. Nodular graphite irons have been produced in irons having as low as 2.5% total carbon. Gagnebin, Millis and Pilling report that the properties are relatively insensitive to carbon over the range of 2.5 to 4.0%. While the limitations on phosphorus are not as rigid as with cerium, the content should not be over about 0.15%. Above this, shrinkage increases and ductility is lowered. However, nodular graphite iron has been obtained in irons with phosphorus up to 0.70%. Since magnesium is a desulfurizer like cerium, its effect is similar to that when cerium is used. A silicon content of over 2% is preferred, and this is obtained when a late addition of silicon is added to serve as an inoculant.

The principal difficulties with the magnesium treatment seem to be the violent reaction of the magnesium, which is highly explosive at molten iron temperatures, and the low percentage recovery of magnesium in the melt. When pure magnesium is added, around 95% is lost. Therefore, many different alloys of magnesium

Photomicrograph of ordinary gray cast iron with graphite in flake form (250 X). Courtesy International Nickel Co., Inc.)

have been tried in order to obtain a higher and more consistent recovery of magnesium. At present the most satisfactory ones appear to be magnesium-nickel and magnesium-copper. In general, the copper or nickel in these alloys range from about 50 to 80%, and it has been found that the violence of the reaction is less, and percent recovery of magnesium is higher at the higher nickel or copper contents. Besides the above two alloys, aluminum-magnesium, iron-magnesium and bismuth-magnesium have proved somewhat effective.

The amount of magnesium actually retained in the melt is critical; with too little magnesium, partially flake graphite structures result; with too much magnesium, free carbides are formed. The optimum magnesium content is influenced by the composition of the iron being treated. In the work by Donoho, 0.05 to 0.07% seemed to be the optimum magnesium content for plain low phosphorus gray iron.

Although most of the development work thus far has concentrated on ordinary gray irons, the process has also been found to be applicable to a wide range of alloyed cast irons, including those having austenitic, martensitic and acicular structures.

The present cost of the magnesium treatment is still high, although probably not as high as the cerium treatment. Alloys containing 30 to 50% magnesium with copper or nickel cost .75¢ to $1.00 per lb. Because of the low recovery using these magnesium alloys, the cost of treatment may run up to as high as $20 per ton. However, if and when large scale production is attained, increased demand may lower the cost of the alloys, and better methods may be developed which will increase the recovery of magnesium.

Heat Treatment

Nodular graphite irons have been successfully heat treated to obtain special properties without any noticeable effect on the graphite structure. They can be readily annealed to give a completely ferritic matrix and thereby increase ductility. Morrogh and Grant report an annealing treatment of 2 hr. as 1290 to 1380 F for unalloyed nodular irons up to ½-in. sections, having 3.5 to 3.9% total carbon and 2.5 to 3.0% silicon. Donoho obtained promising properties on magnesium treated irons with a 1 hr. anneal at 1650 F.

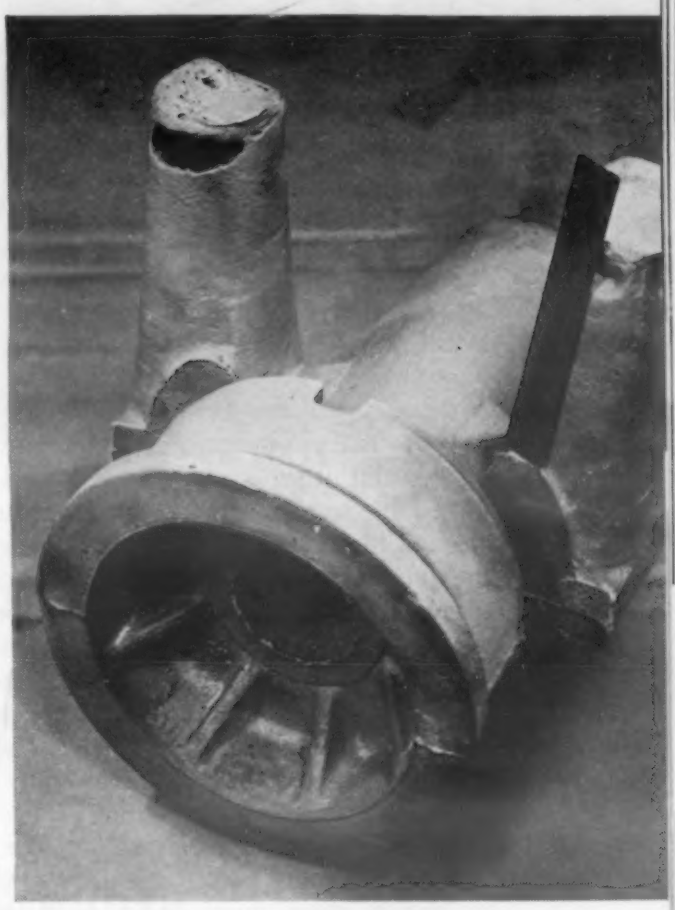
Nodular irons also respond to quenching, tempering and normalizing similar to ordinary gray irons. By quenching and tempering, improvements in tensile strength of up to 100% have been obtained; by normalizing, which involves heating to above the critical temperature and air-cooling, tensile strengths have been increased up to 30%.

Much additional work must still be done on the effects of heat treatment. It is possible that heat treatments will be devised to eliminate the brittleness found in the higher phosphorus irons and to bring out additional valuable combinations of properties.

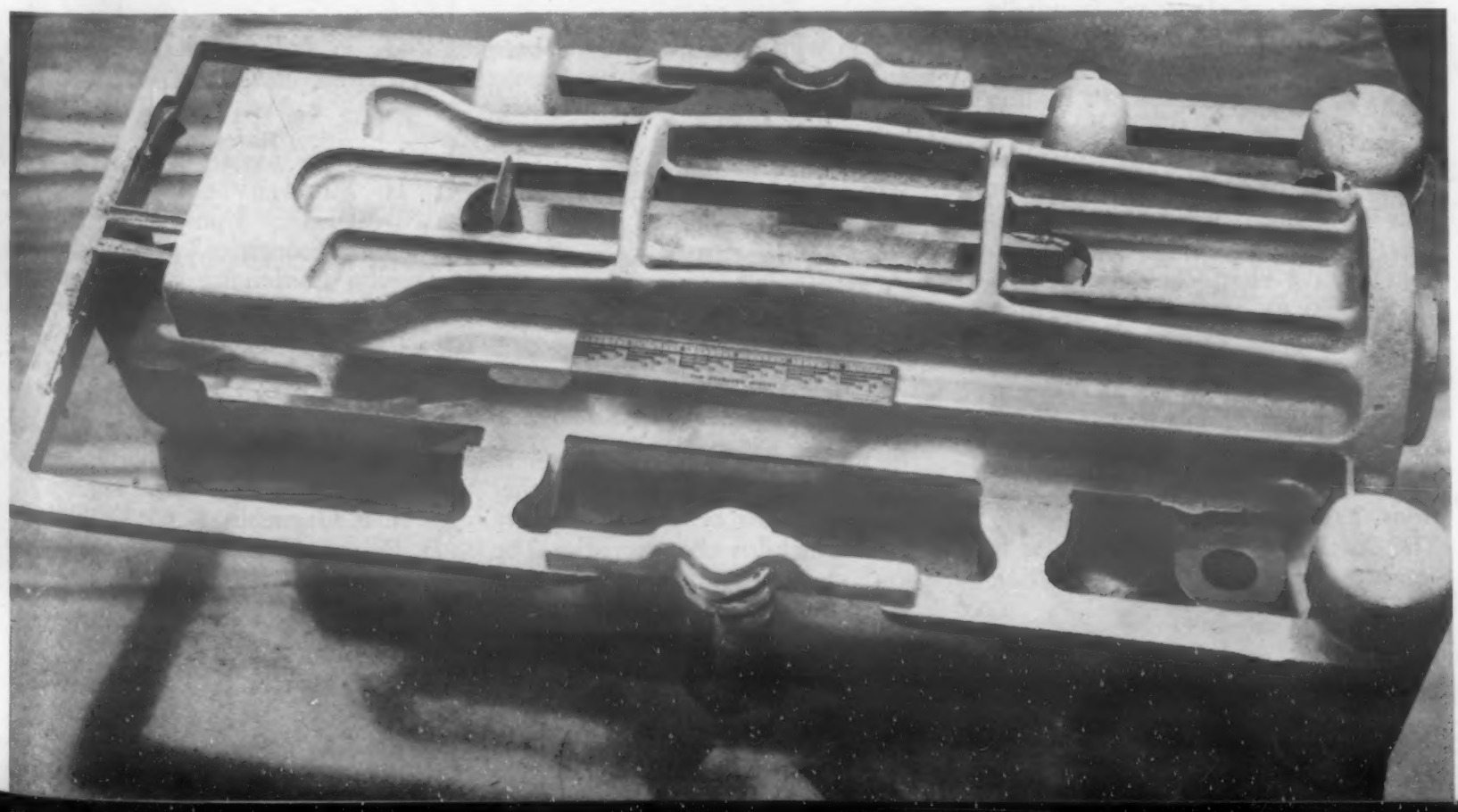
Properties and Characteristics

In general, it might be said that nodular graphite irons lie somewhere between high strength cast irons and malleable iron. For while in many respects they differ from ordinary and high duty gray irons as well as malleable iron, they are in some ways similar to them.

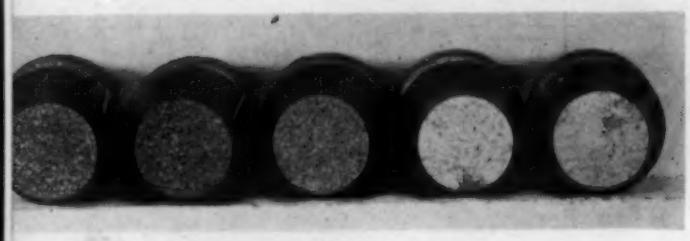
Commutator end made of nodular graphite iron. (Courtesy International Nickel Co., Inc.)



This slack adjuster, requiring a material with high strength properties, is made of nodular graphite cast iron. (Courtesy International Nickel Co., Inc.)



Fractured bars of nodular graphite iron showing fracture appearance. (Courtesy International Nickel Co., Inc.)



The hardness of nodular cast irons, as cast, ranges between about 225 and 300 Bhn. This compares with a range of from 150 to 220 Bhn. for plain flake graphite irons. One of the outstanding characteristics of nodular graphite cast irons is high strength. They have higher tensile and transverse strengths than many high strength alloy irons. As-cast nodular graphite irons have strengths ranging from 65 to 105,000 psi., depending upon the composition and amount of graphite in the nodular form. This range is considerably higher compared with a maximum of about 50,000 psi. for plain gray iron and 62,000 for malleable iron. The strength of nodular iron is not as greatly affected by section thickness as in the case of plain gray iron. For example, the tensile strength in a 0.60-in. section of nodular iron was found to be 99,500 psi. as compared to 76,500 psi. for a 3-in. section. By normalizing and tempering, tensile strength can be further increased, in some cases up to 127,000 psi. and higher.

While irons with a nodular graphite structure are still relatively brittle, they have much better ductility and toughness than most ordinary flake graphite irons and, in some cases, approach or are superior to malleable irons. Plain gray irons have no definite yield points and thus no definite elastic nodulus. However, an "effective modulus of elasticity" is usually assumed to be 25% of the ultimate strength. On this basis the modulus varies from around 12 to 20 million psi., depending on the carbon content. Although, nodular graphite irons also show no definite yield point, they have been found to act somewhat like steel and malleable iron and to have elastic moduli between 20 and 26 million psi. These high moduli are due to their low elastic deformation.

Elongations up to around 6 and 7% on 0.505-in. dia. tensile bars, have been obtained on unannealed nodular irons. Flake graphite cast irons have virtually no elongation. The ductility of nodular cast irons is considerably improved by annealing treatment, which produces a ferritic matrix. In this way, elongations up to 20% have been achieved, thus approaching those of cast steel and being superior to many malleable irons. In one case, cited by Donoho, a magnesium treated iron containing 3.48 carbon, 2.74 silicon, 0.03 sulfur and 0.03% phosphorus was given a simple anneal at 1650 F for 1 hr. The tensile strength was reduced from 101,000 psi. to 77,000 psi. while the elongation was improved from 6.7 to 20.3%.

Impact resistance of nodular irons appears to be considerably improved over that of ordinary gray irons. The Izod impact test results of Morrogh and Grant were rather erratic but nevertheless serve to show the order of shock-resistance of nodular irons. A number of the specimens withstood 120 ft.-lb. without failure and the lowest result, 32 ft.-lb., compares with most high-duty acicular irons.

Some experimental pipe from 8- to 16-in. dia. have been cast and tested, and fittings from 6 to 24 in. in dia. have been tested to failure by bursting. The strengths proved to be from two to three times those obtained with similar castings made of plain gray iron. In addition, the toughness and impact resistance was found to be superior.

Only a limited amount of work has been done on the fatigue characteristics of nodular cast iron. There are indications that nodular iron is not as notch sensitive in static tests as is flake graphite iron. However, in dynamic tests, Morrogh and Grant found them to be more notch sensitive than flake graphite cast iron.

When subjected to high temperatures, gray iron containing flake graphite is susceptible to growth and relatively rapid internal oxidation. To avoid this growth it is necessary to obtain a fine graphite texture, or alloy the iron with chromium. It has been found that nodular graphite cast irons are not nearly as susceptible to growth as plain gray iron and are equal or superior to chromium alloy irons.

Although additional study is required on the damping characteristics, preliminary tests have indicated that nodular cast irons have a damping capacity lower than flake graphite irons and higher than steels.

Processing Characteristics

In most respects nodular graphite cast iron behaves similar to other gray irons in its casting, weldability and machinability characteristics. The casting characteristics after the treatment requires further study; however, fluidity is reported as about the same as flake graphite iron, but feeding requirements are greater since nodular iron is more susceptible to piping.

Nodular cast iron can be arc-welded using essentially the same techniques and procedures applicable to ordinary gray irons. As far as has been determined, the graphite remains in its nodular form during welding. There are some indications of greater hardenability along the weld margin.

Only a small amount of work has been completed thus far on the machinability of nodular cast iron. In the cast condition, and up to 300 and 320 Bhn, it has been found to be as free machining as flake graphite iron of the same hardness, but superior to gray irons having equivalent tensile strengths.

Since nodular graphite cast irons are just now entering into commercial use, there are practically no examples of actual applications. However, the potential applications of these irons are many. The high strength and improved toughness should fit them for many component parts in the automotive, implement, heavy machinery and transportation fields. Because of their excellent resistance to growth and oxidation, they may find use in high temperature service parts.

How successful nodular graphite irons will be depends to a large extent upon further study of a wide range of mechanical and physical properties as well as processing and fabricating characteristics. Although strength and ductility are usually important considerations, the selection of cast iron frequently hinges on other properties, such as wear resistance, corrosion resistance, bearing properties, and the like. So properties such as these must receive further study in order to learn where this new engineering material fits in best.

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Forged steel pieces and steel plate are welded together to make the fabricated crankcase.

Several Steel Forms Combined in Heavy-Duty Weldments

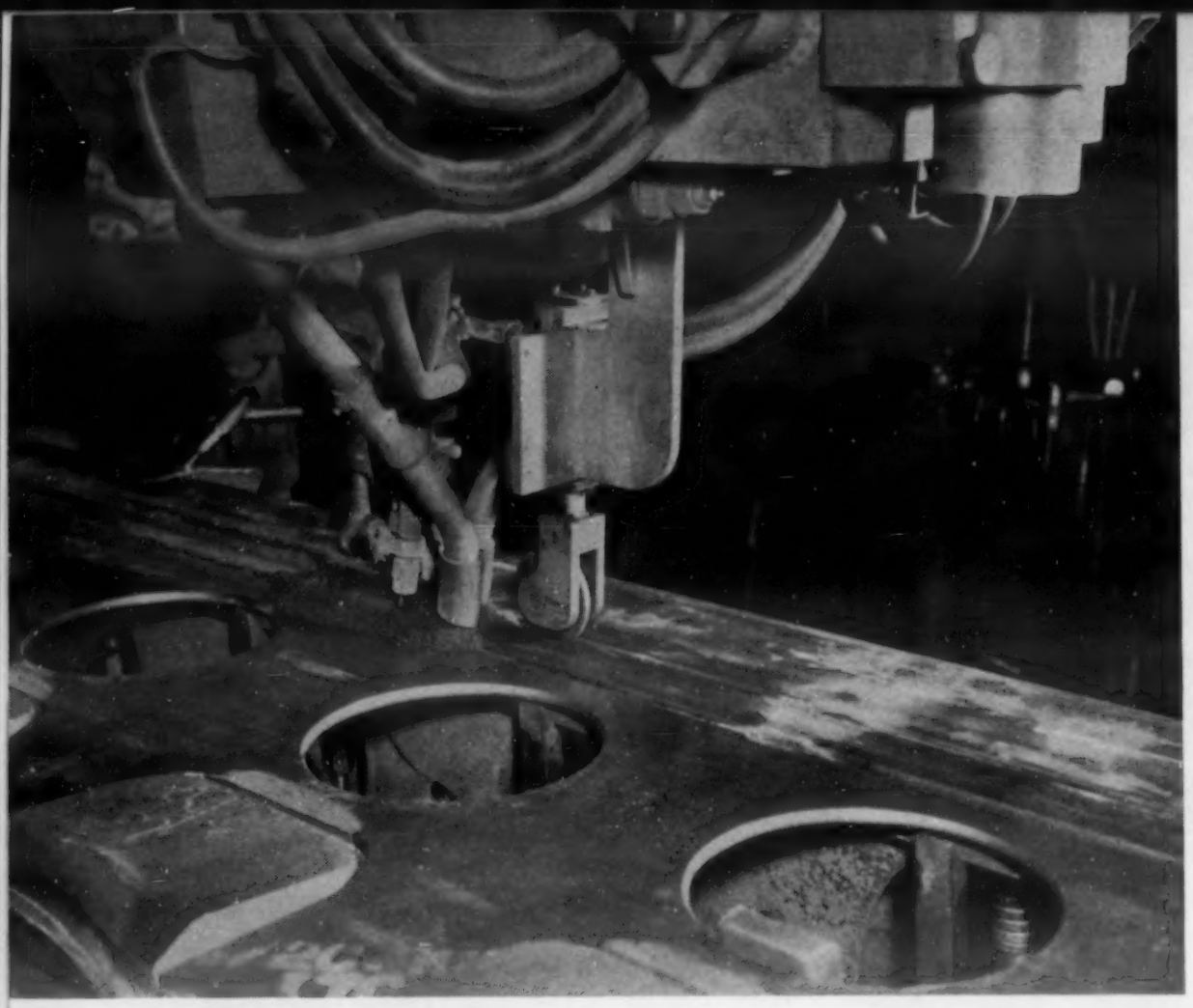
by **KENNETH ROSE**, Western Editor, Materials & Methods

Large diesel crankcases built up of steel forgings, plate, tubing and bar stock have advantages of light weight, lower cost, and longer service life.

● BUILDING THE POWER PLANT for a diesel locomotive involves a careful choice of materials with a view not only to adequate performance in service, but also to efficient fabrication by modern methods, and to ease of making repairs. The investment in a diesel locomotive may run to half a million dollars, and the buyer expects this investment to represent the best of materials and a well-thought-out design that takes into consideration all the problems of operation and of repair in case of damage.

The diesel engine designed by the Electro-Motive Div., General Motors Corp. for its locomotives is a 45-deg. V-type engine built in sizes from 6 to 16 cylinders, in which the crankcase and oil pan serve as the equivalent of a motor block. It contains the cylinders and the stress members, water, oil, and air passages, and crankshaft bearings. The cylinders have individual heads.

After careful study of fabrication possibilities and service factors, it was decided to build the crankcase as a weldment. It is produced as a fabricated combination of steel forgings, plate, tubing, and bar stock. Until recently the cylinder head retainers were steel castings, but these have been converted to forgings. Most of the steel is a welding grade of SAE



Parallel heads make two blind welds by the submerged arc welding method in one pass.

Positioners permit downhand welding for most of the fabrication.

1020, but stress plates are of low alloy-high strength steel.

Some of the considerations that induced the selection of welded fabrication over cast are given by Electro-Motive Div. engineers as follows:

1—The weldment avoids difficulties with porosity. Even after careful inspection of the rough casting it sometimes happens that machining opens up defects. This means that costly repairs have to be made. If repairs are extensive, it is frequently necessary to stress relieve, and sometimes the piece and all the work put into it are lost when warpage occurs. With the weldment, repairs are easier to make, and rejects are greatly reduced.

2—The weldment is lighter. In the steel casting of intricate form it is necessary to let wall thicknesses be heavy enough so that the metal will run. With the weldment the heaviest plate in the structural part of the crankcase is ½-in. stock, in the low alloy-high tensile stress plates.

3—Corrosion is lessened in the built-up crankcase.

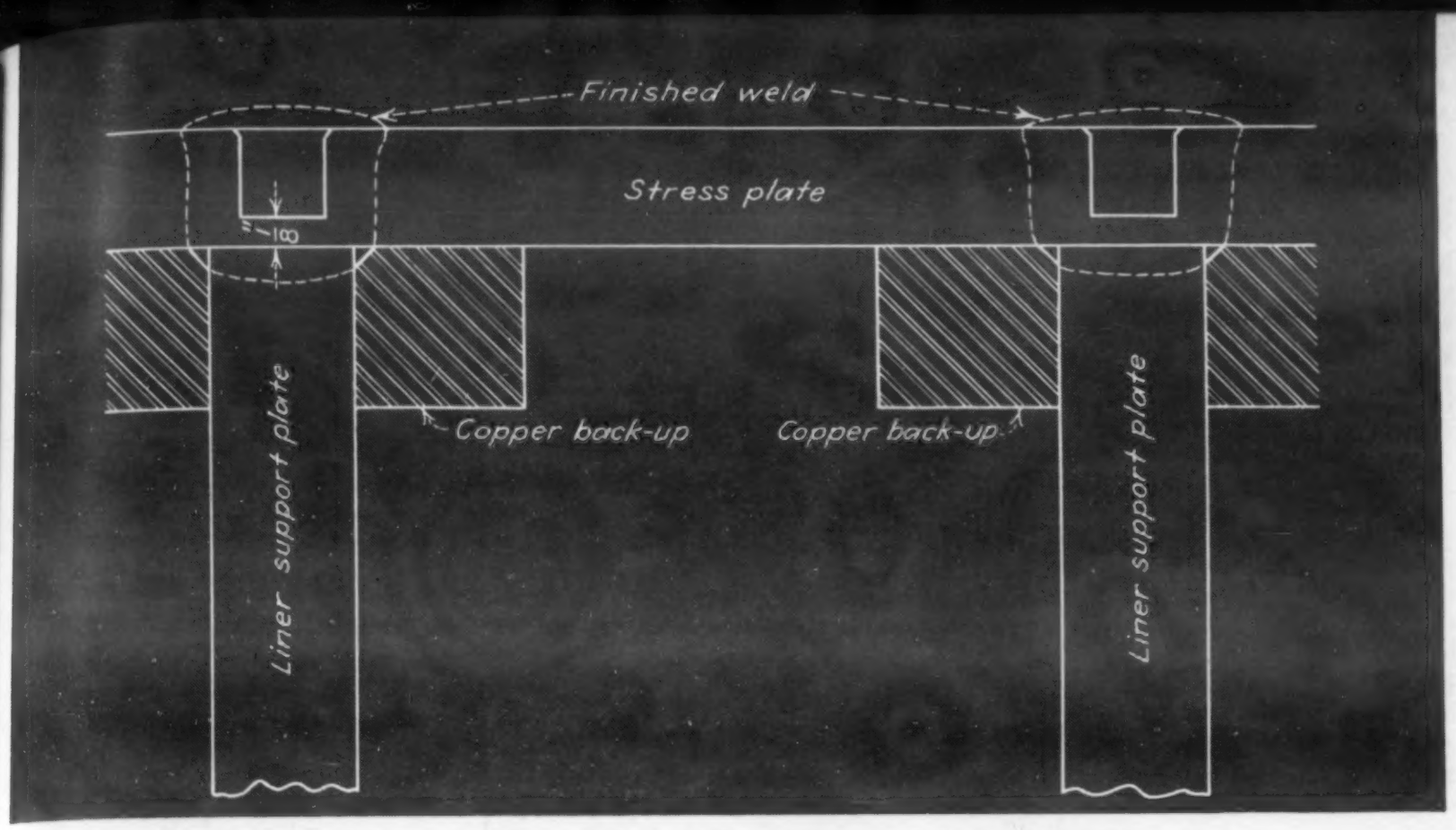
4—Costs are lower. While the rough casting would be somewhat cheaper than the rough weldment, the final cost of the weldment is lower.

5—Repairs on damaged engines are easier to make. Walls can be cut out and replaced in the weldment with much less difficulty than a similar repair could be made in the cast crankcase.

6—Records indicate that the weldments have a longer service life.

In the design of the crankcase weldment the main frame stress members, which provide bearings for the crankshaft at their lower extremities and tie into cylinder supports above, are heavy steel forgings. Stress plates of low alloy-high tensile steel, ½ in. thick, support the cylinders themselves and transmit the firing load to the main frame stress members. All other plate and bar stock is SAE 1020 steel. While most of the crankcase is built up from plate, bar or tube, a few small pieces of irregular form are produced as forgings and welded into the assembly. These include, in addition to parts already mentioned, the cylinder head retainers, the injector control shaft blocks, the camshaft blocks, the crab studs, and the corner support blocks.

All cylinders are of 8½-in. bore and 10-in. stroke, and all use the same heads. Cast iron liners with integral water passages are used. The liner is a slip fit, and sits on two seal



Sketch showing positioning of parts for blind welding support plates to stress plate.

rings. Heavy crab studs hold the cylinder heads down. The liner is ⅜ in. thick at the top, and 5/16 in. at the bottom. The interior wall is honed to a surface of 18 to 30 micro-inches average roughness, r.m.s. Pistons are of cast iron also. Forged main frame stress members are made of SAE 1020 steel, and the cylinder head retainers, also forged, use SAE 1022 steel.

Welding Procedure

In planning the conversion from a casting to a weldment, it was intended that most of the welding would be automatic. The size of the weldment and the relatively high stresses for which it must be designed indicated that arc welding would be the preferred process. Wherever long, straight welds, or welds following a simple pattern are used, automatic arc welding is being used or is a possibility.

Typical of the automatic arc welding and of the ingenuity in adapting it to the weldment is the process of joining the liner support plates to the stress plate. Two liner support plates each ⅝-in. thick must be welded to the ½-in. stress plate by continuous welding, the support plates parallel and about 3 in. apart, and perpendicular to the stress plate. The support plates are of SAE 1020 steel, of firebox quality. Welding these two plates at right angles to the face of the stress plate in the usual way would have required four beads, and the two inner beads, between the parallel plates, would have been awkward for either machine or hand welding. It was decided to weld through the stress plate, fusing both of the support plates by blind welds made in one pass.

In preparation for the welds, two parallel notches ⅜ in. deep are cut in the face of the stress plate on a planer. This lets only ⅛ in. of metal remaining at the root of the grooves. The grooves run the entire length of the stress plate, and are square.

The welds are made by two welding heads mounted on one carriage and positioned one over each groove, so that both bonds are made in the same single pass. The liner support plates are positioned against the under side of the stress plate, clamped in position, and copper back-up bars are clamped along each side of each plate at the line of the weld. These bars serve as chills as well as prevent escape of the molten metal when the arc burns through the root of the groove. The positioning of the parts is shown in the accompanying sketch. The Lincolnweld process is used for these submerged arc welds. Wire 7/32 in. in dia. is supplied to each head, and the two welds are made at the rate of about 12 in. per min.

The machine draws about 1,000 amp. at 35 v. A guide wheel running in one of the grooves keeps the two welding heads in the proper paths; chutes just ahead of the arcs deposit the granular flux that shields the arc. The inside corners on the square copper bars are slightly chamfered to permit formation of a fillet at the base of each weld when it burns through the top plate. The arc fuses the remaining ⅛ in. of metal in the stress plate with the underlying support plate and fills the groove, so that the single pass welds both support plates in place under the surface of the stress plate and lets a flush surface on the stress plate itself. Manual arc finishing is necessary at beginning and end of the beads.

Despite the size and irregular shape of the crankcase, various types of positioning devices make it possible to do 90% of the manual welding in the downhand position. For attaching the forged blocks and making other short welds along the tops of the cylinders the weldment is cradled in a special frame, in which heavy steel pipes support the work while permitting its adjustment in relation to the welding. More difficult positioning is accomplished by large positioners of conventional type, holding the work by clamping to a table that can be moved in several planes. A platform for the operator gives access to the locations to be welded even when the huge piece must be swung 6 ft. or more above the floor.

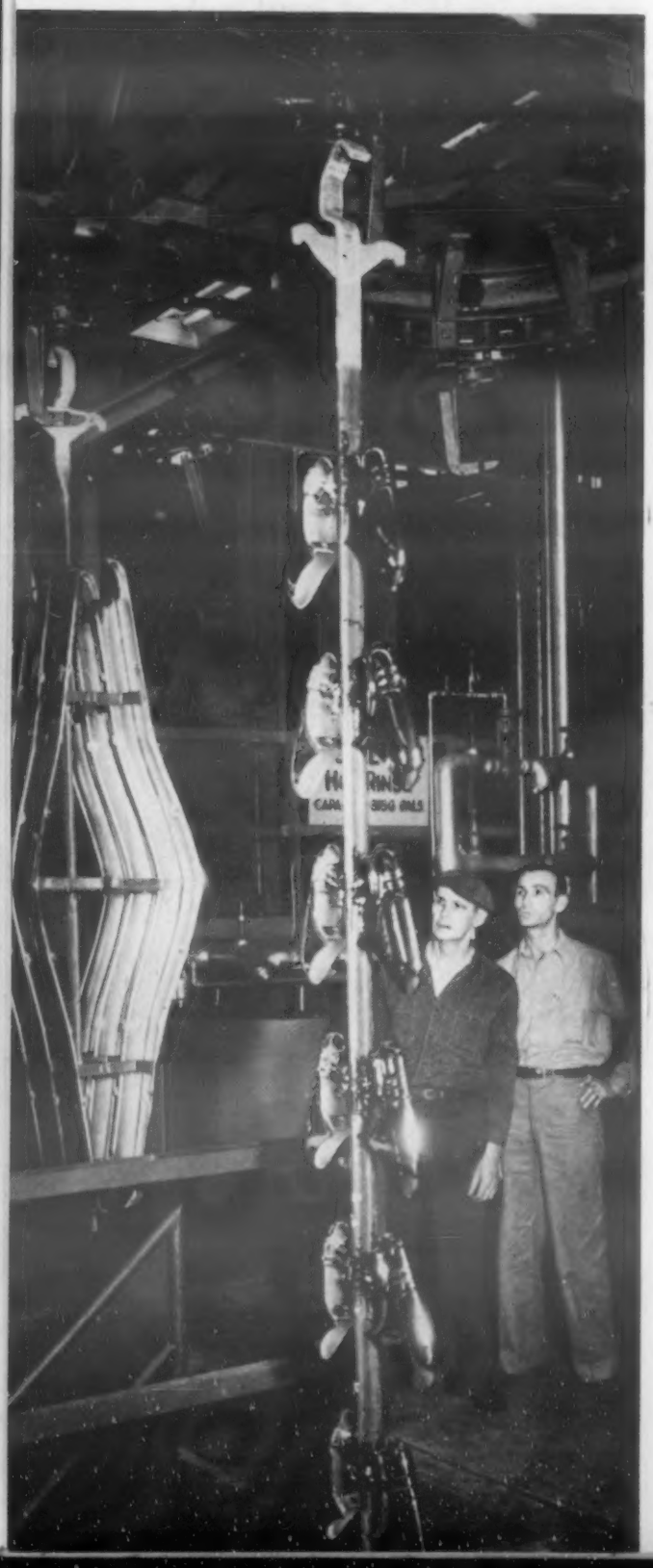
Grooves for manual arc welding are machine prepared. The quality of the work is maintained by visual inspection, by magnetic powder inspection, and by probing. The weldments are stress relieved before machining, in line with customary practice, and a final careful running test of the completed engine searches out any defects that might not have been revealed by the inspections of the weldments and subassemblies.

Bright Nickel Plating Provides Low Cost Quality Finish

Here is detailed, practical information on how economical finishes and decorative effects otherwise unattainable are produced by bright nickel plating.

by **JEROME L. BLEIWEIS,** Metal Finishing Consultant

Automobile bumpers can be chromium plated more economically by eliminating at least one coloring operation through the use of bright nickel plating.



● BRIGHT NICKEL PLATING provides a valuable means for cutting finishing costs through direct labor savings, and also readily produces results previously difficult or nearly impossible to attain. However, as yet, the full potentialities of bright nickel plating are not being utilized. Some platers use it as if it were the old dull white plate; others use it as a heavy flash plate over buffed surfaces, this heavy flash plate requiring either no subsequent buffing or only light fanning. There is no objection to this limited use of bright nickel providing that its more expansive possibilities are utilized as well.

It is the purpose of this article to describe how bright nickel plating can be used most effectively to obtain the desired decorative finish at low cost; also to describe cases in which a final effect, not possible by other means, can be obtained.

The most important characteristic of a good bright nickel solution under correct operating conditions is that, in contrast to the conventional electrodeposits, as the plating thickness increases so does the brightness of the finish. The limiting brightness is the intrinsic limitation of the brightness of the deposit itself. The higher the finish of the basis metal the more rapidly is the limiting brightness reached. Thus, on highly buffed brass, for example, only a flash or heavy flash is required to achieve maximum brightness and planar reflectivity.

Bright nickel plating, if correctly applied, can be often used to eliminate one or more costly hand polishing or buffing operations. For many jobs the substitution of bright nickel for dull white nickel acts not only as a substitute for a subsequent buffing operation, but in eliminating this previously used buffing step, an increase in the final specular property of the deposit is achieved. Bright nickel plating baths, furthermore, are generally "hot" nickel baths and are more concentrated baths in terms of nickel salt concentrations than cold white nickel solutions. This permits the imposition of high current densities and consequently increases plating rates, which, in turn, means substantially increased tank production.

A typical bright nickel plating bath contains the following:

Single nickel salts—$NiSO_4$.
$7H_2O$ .....48 oz. per gal.
Nickel chloride—$NiCL_2.6H_2O$
8 oz. per gal.
Boric acid—H_3BO_3
5 oz. per gal.

To this bath are added quantities of addition agents both organic and inorganic. These addition agents are sold as proprietary products by various manufacturers whose recommendations for concentrations and operating conditions are usually specific and should be adhered to. The addition agents have the dual function of acting as anti-pitting agents and as brighteners, the correct combination of both classes yielding the smoothest and most brilliant plate.

The bath operates at 150 F. With a ph of 3 to 5, beautiful results are produced without burning at close to 100% current efficiency and at current densities of 75 amp. per sq. ft., and where necessary even at 100 amp. per sq. ft., or a plating rate of from 0.004 to 0.005 in. per hr. It is ad-

visable to agitate the solution; this is accomplished most effectively by driving the work rod back and forth, either perpendicular to or parallel to the bus bars, 30 to 45 cycles per min. Bright nickel solutions, such as the above, may be operated successfully without work rod agitation, but with agitation the limitations on current density and brightener concentration are considerably lower and the results qualitatively better.

Steel

Most steel is finished in some manner, primarily as a means for retarding corrosion. Where appearance is not a primary factor cadmium, zinc, tin or organic finishes are most widely used, depending upon the use to which the steel product is to be put. However, where final beauty is also needed, a bright, burnished, or highly buffed final effect is often required. The most frequently used final finish for this purpose is chromium. Gold, silver, brass, copper, nickel itself, and other finishes may also be used. In most cases, however, the decorative effect of the final plated finish will depend upon the decorative quality of a nickel undercoat. Exceptions include those applications where metals like copper, silver or brass are deposited and buffed, without the use of nickel undercoats, although it is believed that in many of these cases the use of bright nickel and a flash of copper, brass or silver would be qualitatively and economically superior.

Where a bright finish without specular reflectivity is required, and the steel part is relatively smooth and clean, the application of bright nickel directly followed by chromium or any other flashed coating is an excellent method by which burnishing or coloring may be eliminated. The finish may not be identical to the burnished or colored finish, but where acceptable will be cheaper. This is evident when the base metal is a highly reflecting grade of cold rolled steel. The finish, except for draw marks and surface defects, will approach the reflectivity of a buffed surface.

Where a burnished finish is required, burnishing followed by 5 min. of bright nickel and a final flash coat of whatever the finish plate is to be is frequently more economical than if the final metal applied on the burnished steel had to be burnished itself to bring up its luster.

Where a buffed surface is required, the following cycle may be employed, except where specifications dictate otherwise: (1) Polish the steel (grit sizes depend upon initial condition of steel). (2) Finish polish using 220 grease wheel or buff with greaseless compound of the Lea type. (3) 5 to 15 min. bright nickel. (4) Chromium plate (or any other plate).

When a better final finish is required, the part may be copper plated and colored before bright nickel plating. In such cases the nickel plating cycle can be cut to 1 or 2 min. where no thickness is specified, or instead of copper plating, a nickel fanning operation before chromium plating may be sufficient. Where copper is specified under the nickel, the use of a bright copper followed by bright nickel will also yield a final chromium-plated finish entirely satisfactory without resorting to buffing. These observations hold particularly for surfaces having few or no flat areas. Contrast this cycle with one not utilizing bright nickel: (1) Polish the steel (as above). (2) Finish polish or (as above). (3) Buff. (4) Copper plate. (5) Color copper. (6) Nickel plate. (7) Color or fan. (8) Chromium plate. There are two, or at least one additional buffing operation here, not even considering the additional plating cycle time or the necessity for reracking or rewiring.

Where the final finish required is copper, brass or silver, and specifications do not dictate otherwise, the slower processes of brass, silver, or frequently copper plating are replaced by the high-speed bright nickel and a flash of the final deposit, eliminating the final buffing. In the case of silver the advantages are evident in terms of the saving of silver metal, the replacement of the slower plating cycle, and the elimination of silver coloring. Copper and brass would both have to be plated thick enough to eliminate the possibility of cutting through these soft plates in the coloring process. This danger is obviated by the use of a thinner bright nickel plate with the elimination of copper or brass coloring.

A practical illustration of the use of bright nickel occurred where automatic record player spindles were to be plated according to the following specifications:

Copper	0.0001 in.
Copper and nickel..	0.0005 in.
Final chromium....	0.00001 in.
Buffed finish	

The spindles were finished on a Lea C wheel, wired 90 to a rack, copper plated, bright nickel plated 7 min. and chromium plated. Production was scheduled so that eight cycles passed through the nickel tank per hour, nickel being the most time consuming operation, or a total of 720 pieces per rack hr. No buffing was required. The elimination of the coloring and consequent rewiring operations enabled this particular shop to handle the job profitably, an impossibility otherwise.

Brass, Bronze and Copper

These basis materials lend themselves particularly well to bright nickel plating. Whenever buffing is required, they are cut and colored before plating. There is never any necessity for a copper plating and coloring operation on any of them. The brasses can be considered as typical; the processing of the others is the same, with possible cleaning differences. A brass may be bright dipped in any typical sulfuric acid-nitric acid dip for this purpose, or bright dipped and burnished followed by several minutes of bright nickel; and, if specified, finally plated with chromium, gold, silver, etc. The bright dip or burnished luster is enhanced considerably, so that for many geometric shapes it is difficult to distinguish between them and buffed finishes on the same parts.

For highly buffed plated brass articles a typical cycle would be: (1) Cut with tripoli. (2) Color with lime. (3) Bright nickel plate 1 min. or to specified thickness. (4) Final chromium or other plate. It is even possible to eliminate the coloring operation where the tripoli binder is readily saponifiable and where the cutting job does not cake or smear compound all over the surfaces to be plated.

The use of dull nickel requires a nickel coloring operation which is eliminated only by flash plating nickel on the brass, a practice which may be frowned upon where service requirements dictate a substantial nickel plate.

To illustrate the versatile use to which this bright plating cycle can be put, consider the approach recommended to one manufacturer for a production run of brass holders. The holders were about 5 in. long, ⅜ in. wide and ¼ in. thick. The front and rear surfaces were flat and the end and side surfaces had smooth radii of curvature. The holders were to simulate buffed nickel parts. The procedure recommended and adopted was: (1) Degrease. (2) Quick bright dip. (3) Burnish 20 min. (4) Cut and color only two flat surfaces. (5)

Four min. bright nickel. In this manner the necessity for buffing four additional surfaces was eliminated and the finish was excellent. Innumerable curved surfaces can and should be handled in this manner for the best combination of economy and quality.

On brass and other soft metals, coloring generally leaves brush or buff marks which will be reproduced by any plate flashed over the brass. In many cases these cloudy lines are undesirable and can be eliminated by rouging. Bright nickel plated on colored brass, and frequently even on brass that has only been cut with tripoli, will obliterate these buff marks completely with as little as 2 min. of plate. Coloring bright nickel plate itself with lime does not leave readily evident buff marks because of the hardness of the bright plate; this eliminates the necessity for using rouge as a buffing composition should coloring or fanning be necessary.

Coloring of copper and its alloys has always been considered a skilled operation to be entrusted only to polishers sufficiently experienced to handle it. Besides production speed requirements, it was important to minimize brush lines, run whatever lines remained all in the same direction, and obtain maximum color by correct application of compound, wheel pressure, etc. Where, subsequent to the coloring operation, bright nickel plating is to be used, it is possible to employ relatively inexperienced men and to stress speed at the expense of color quality. The bright nickel plate will generally accomplish what the color buffer has not. While this does not mean that even the poorest color work is redeemable with bright nickel, maximum copper or brass color is not necessary and multidirectional brush marks are not objectionable.

Cycles and Results of Bright Nickel Plating

Basis Material	Result	Most Economical Cycle	Remarks
Steel	Bright finish without specular reflectivity.	2-15 min. bright nickel. Final plate (chrome, flash gold, etc.).	Time in nickel depends upon finish on original steel and upon specifications.
Steel	Bright burnished finish.	Barrel burnish 15 min. to 1 hr. Bright nickel 5 min. Final plate.	Eliminates necessity for burnishing finally specified metal.
Steel	Buffed finish or finish having high specular reflectivity.	Polish steel. Finish polish 220 grease or buff, greaseless compounds. Bright nickel 5-15 min. Final plate.	Copper plate (bright) where specified before nickel. If required fan nickel.
Brass, Bronze or Copper	Bright finish without specular reflectivity.	Bright dip (nitric-sulfuric acid type). Bright nickel 1 min. up. Final plate.	Plate becomes brighter with time; duration depends upon texture of bright dipped surface, desired brightness, and thickness specification.
Brass, Bronze or Copper	Very bright, burnished or simulated buffed surface.	Bright dip. Burnish 15 min. to 1 hr. Bright nickel 1 min. up. Final plate.	Curved surfaces may look like buffed surfaces with sufficient nickel.
Brass, Bronze or Copper	Buffed finish.	Cut with tripoli. Color with lime. Bright nickel plate. Final plate.	Plating time is a function of specification. Coloring can be eliminated.
Zinc Die Castings	Bright finish.	Copper (0.0002 in. min.). Bright nickel 1 min. up. Final plate.	—
Zinc Die Castings	Buffed finish.	Polish (parting lines). Cut with tripoli. Copper plate (0.0002 in. min.). Bright nickel plate 1 min. up. Final plate.	Coloring can follow the tripoli stem primarily as a means to remove smears and compound cake.
Aluminum Alloys	Buffed finish.	Polish and buff as required. Zincate immersion. Copper plate. Bright nickel plate 1 min. up. Final plate.	Omit polish and buffing where not demanded.
Lead-Base Alloys	Buffed finish.	Cut with tripoli. Bright nickel 15 min. Final plate.	Coloring may be required to clean surface and reduce scratch lines. Nickel cycle would then be reduced.
Any Ornate Material	Bright or simulated buffed finish.	Build up with bright nickel to desired brightness. Final plate.	Particularly applicable where buffing is expensive or impossible.
Solder Joints	Cover solder and maintain buffed surfaces.	Cut and color. Bright nickel 2 to 4 min. Final plate.	—
Any	Replate silver, gold, copper, etc., with buffed finish.	Strip old plate if required. Buff suitably. Build up with bright nickel. Final plate.	—
Old Nickel Plate	Replate without stripping nickel where possible.	Color nickel. Replate bright nickel. Fan out lines of demarcation between old nickel plate and underlying metal.	—

This table is based on the use of a bright nickel plating solution having the approximate composition of the bath noted in the text, operating at 150 F, 75 amps per sq. ft., with agitation.

Zinc Die Castings

It is mandatory, whenever zinc die castings are plated, to include a nickel plating operation. Copper, brass, gold or silver plated directly on the die casting slowly diffuses into the casting with consequent deterioration. The usual procedure to eliminate this difficulty includes the deposition of special nickel coatings directly upon the basis metal or more usually, the deposition of conventional or bright nickel upon a previously deposited copper undercoat. Using the latter procedure, a typical cycle for plating zinc die castings requiring a highly buffed final finish is: (1) Polish out parting lines. (2) Cut casting with tripoli. (3) Color (optional). (4) Copper plate. (5) Bright nickel plate. (6) Chromium or other final plate.

The results from correct use of this procedure are excellent. Buffing operations on the copper or nickel, particularly where the castings have sharp edges, are difficult. Cutting through

to the underlying basis metal is a frequent result.

Where a buffed finish is not required, beautiful results may be obtained by the use of a copper, bright nickel cycle plated upon the usually bright die cast skin. The resulting finish is not of buffed quality but is sufficiently attractive for many requirements and is the kind of bright finish not obtainable in any other manner.

Aluminum and Aluminum Alloys

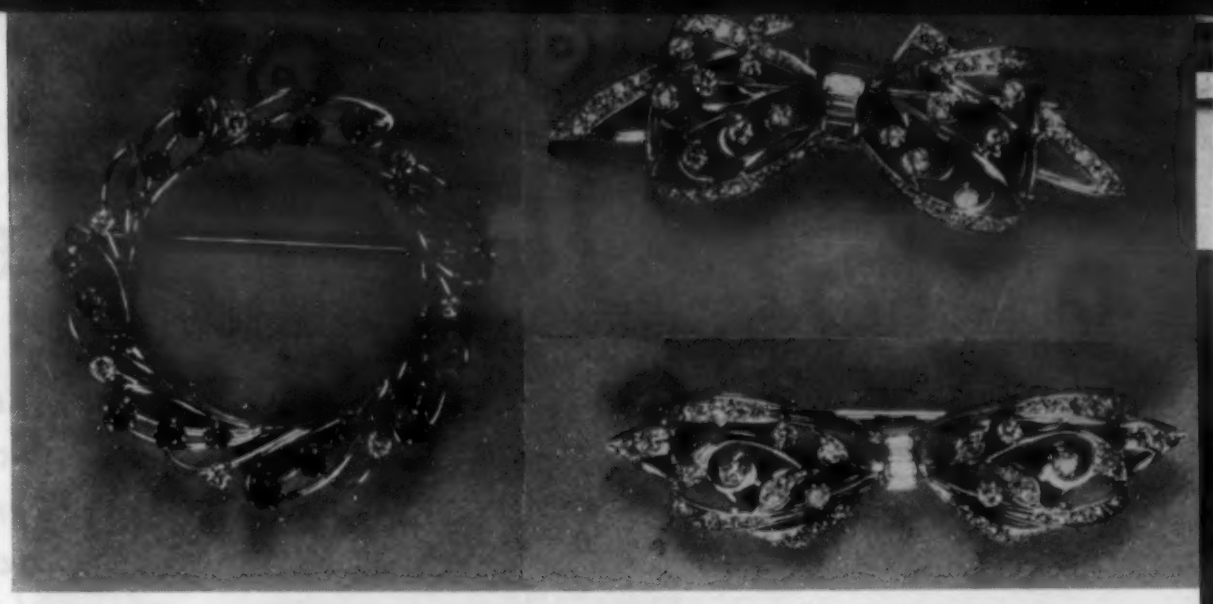
With the development of the Zincate immersion process for plating on aluminum and its alloys, commercial plating of aluminum has become a reality. Any plating shop can, with very little additional installation, plate aluminum as readily as steel, copper and its alloys, and zinc die castings. A typical cycle for electroplating aluminum would be: (1) Polish and buff as required. (2) Zincate immersion. (3) Copper plate. (4) Bright nickel plate. (5) Chromium or other final plate.

What has been said previously about bright nickel plating of brass applies fairly closely to aluminum. As in the case of zinc die castings, intermediate buffing operations should be eliminated or minimized to obviate the possibility of cutting through to the underlying aluminum base.

Lead-Base Alloys

Lead-base alloys find application primarily where ornamental qualities, ease of manufacture (through low temperature casting) and inexpensive materials are fundamental and where strength considerations are notably absent. Frequently they are used in conjunction with other metallic materials, for example, as ornaments easily soldered on brass.

Most of these alloys require finishing. Buffing of the basis metal will not result in a highly colored finish. The intrinsic softness and low temperature flow characteristics cause buffing to yield a "dragged" effect. However, by buffing for smoothness, plating variously, and coloring the plate, the desired highly buffed ornamental effect may be obtained. A typical cycle would be: (1) Cut with tripoli. (2) Color (optional). (3) Copper flash (optional). (4) Bright nickel plate. (5) Color (optional). (6) Chromium or other final plate. It is possible to obtain excellent results with the minimum cycle: (1) Cut with tripoli. (2) Bright nickel plate. (3) Chromium etc.



Buffing can be eliminated on intricately shaped parts through use of bright nickel undercoats.

The justifications for each of the optional steps in the longer cycle are several. Coloring cleans up the lead surface, leaving it free of compound smears or cake, and reduces the number of scratch lines. To the writer's knowledge there are few satisfactory electro-alkaline cleaners for lead. As a matter of fact, the shorter the soak alkaline cycle for lead before plating the less surface discoloration is experienced and the better the final results. For this reason it may be advisable to color lead as a surface cleaning step and then follow with a short soak clean, if the tripoli operation is a messy one. The smoother surface resulting will also reduce the bright nickel plating cycle and frequently will eliminate the necessity for nickel coloring.

Copper flashing is never required unless the preplating cycle has been a dubious one. The copper flash then acts as an information stage. Rebuffing is easily performed over flashed copper but is very difficult once nickel has been applied. A bad looking copper flash plate becomes a sign indicating a cessation of subsequent plating operations pending rebuffing of the lead. A good looking copper flash is a go-ahead signal. Nickel coloring is optional in the sense that the schedule previous to nickel plating may have yielded a result not entirely satisfactory without coloring or fanning. For some grades of jewelry or expensive ornamental objects nickel coloring may be demanded.

The writer was called in by a manufacturer who produced large flat gold plated lead belt ornaments and buckles. His plating cost was excessive, the following cycle being employed: (1) Cut (tripoli). (2) Color (rouge). (3) Copper flash. (4) Nickel plate 3 min. (5) Copper plate. (6) Color copper. (7) Flash nickel plate. (8) Fan nickel. (9) Gold plate. (10) Rouge gold.

It would have been difficult to find any more finishing operations to include in this cycle. The cycle recommended and adopted was: (1) Cut and color with tripoli. (2) 15 min. bright nickel. (3) Flash gold.

Other Applications

Where ornate soft metal (lead) objects require a bright or simulated buffed finish, the desired result can frequently be attained by building up the brightness with however much bright nickel is required to do so. Frequently it is impossible to buff ornate objects except for the minimal high points; sometimes buffing ornate objects completely becomes a very expensive operation. In both of these instances the economical solution would be a bright nickel undercoat.

Where solder is exposed on parts, the use of bright nickel plate will cover the solder and maintain or enhance all buffed surfaces on the same object. Solder coverage can be accomplished employing the following cycle: (1) Cut and color. (2) Bright nickel plate to cover solder. (3) Final plate. Where lead ornaments are soldered to brass or to other basis materials, the above approach serves the dual purpose of coverage and the means for brightening the ornaments.

Old silverware or copperware may be excellently replated after suitable polishing and buffing by building up with bright nickel and flashing silver, copper, etc. followed by lacquering. It is even possible at times to replate over old nickel by stripping whatever plate is on the nickel, coloring the nickel, even cutting through in areas, replating bright nickel on the old nickel, fanning out the boundary lines which show up, demarking the areas which were cut through, and final plating. This procedure, where possible, is far more economical than procedures requiring that the old nickel be stripped completely.

Steam Atmosphere Used to Heat Treat and Improve Surface Properties

by F. L. SPANGLER, Leeds & Northrup Co.

Many ferrous and nonferrous materials can be processed at temperatures up to 1000 F in steam atmospheres to produce a thin, clean, and tenacious oxide film on the surface.

• THE POSSIBILITY OF USING a steam atmosphere for tempering and for producing thin oxide films on ferrous and nonferrous metals has been known for a long time. But only within the past few years has the process been developed for wide practical use. The basic advantage of steam atmosphere treatment is that it provides a clean scale-free surface. One of its principal uses is in conjunction with tempering and strain relief of ferrous parts and annealing of certain nonferrous materials. In addition, the oxide film produced by the process has other specific properties which make it applicable for other purposes. It can be used to increase surface hardness, improve wear resistance and corrosion resistance, and increase tool life. In some cases it shortens or eliminates pickling and offers a method of coloring steel.

The coating produced by this steam treatment is a thin tightly adherent oxide that averages about 0.0002 in. in depth. On iron and steel, blue magnetic iron oxide, Fe_3O_4, is formed. On nonferrous metals, the steam atmosphere inhibits oxidation and prevents discoloration and scaling. The resulting surface has no characteristic color. It is slightly darker and duller than the untreated surface, and its exact nature depends upon the metal being treated.

Materials that have been successfully treated up to this time are carbon steels, high-speed tool steel, cast iron, sintered iron powder, beryllium copper, brass, and aluminum alloys.

While others have not as yet been tried, it is believed that the process will be suitable for any readily oxidized metals.

The process briefly consists of exposing the metal surfaces to a steam atmosphere at temperatures up to around 1000 F. The work in the furnace is first brought up to a specified temperature in an air atmosphere. It is held at this temperature while steam is fed into the furnace to purge out all the air. After purging, the load is heated to the soaking temperature and held there for a specified time with steam continuously flowing through the furnace. The work coming from the furnace is either air cooled or liquid quenched.

Batch-type furnaces specially designed for steam atmosphere treatment give most satisfactory results. An accompanying cut-away drawing shows the essential details of such a furnace designed by Leeds & Northrup Co. The furnace is of the electric forced convection type, and is capable of temperatures up to 1150 F. Steam is fed through an inlet in the bottom of the furnace and exhausts through a flapper valve. Any reliable source of steam, from either a process steam line or a small electric or gas-heated steam generator, is satisfactory. For continuous production work, about 50 lb. of steam per hr. is generally required. The cost of the steam atmosphere runs around a few cents per 100 lb. of load. Inside the furnace the pressure ranges around 4 in. of water, and is regulated by a flapper valve in the furnace lid.

Ferrous Metals

The treating cycle for ferrous metals consists of four steps: (1) The work after being loaded in the furnace is preheated with a normal air atmosphere to a temperature of 650 to 750 F. This prevents condensation of steam on the cold work. (2) When furnace reaches the preheat control temperature, the furnace is purged of air as rapidly as possible by incoming steam. Purging time is approximately ½ hr., and about 50 volume changes are required. (3) The load is then heated to the final treating temperature and soaked for the required time with steam continuously flowing through the furnace. (4) Parts are removed from furnace and either air cooled or liquid quenched.

To insure satisfactory results, the work must be cleaned properly before loading in the furnace. The work, fixtures and containers should be thoroughly cleaned and dried, either by vapor degreasing, or by using an alkali bath followed immediately with a hot water rinse.

One of the principal uses of steam atmosphere treatment is for scale-free tempering and strain relief of ferrous parts in the temperature range from 750 to 1150 F. Because of the steam atmosphere, ferrous metals come from the furnace with a uniform blue oxide finish that is desirable for many parts and tools. Some typical steel parts which can be tempered in this range after hardening in an atmosphere furnace are bolts, aircraft structural parts, and diesel injection system fittings. Parts that have been strain-relieved in the steam atmosphere after cold working include cold headed bolts and deep drawn parts such as bearing cups.

Besides providing a scale-free tempering process, steam treatment produces a better surface finish and improves machinability. A manufacturer of cold formed bearing shells reports that the steam atmosphere treatment results in a better surface finish and a 300% greater tool life

in a subsequent precision machining operation. The former method was to stress-relieve or temper in an air atmosphere and then clean by shot blasting prior to machining.

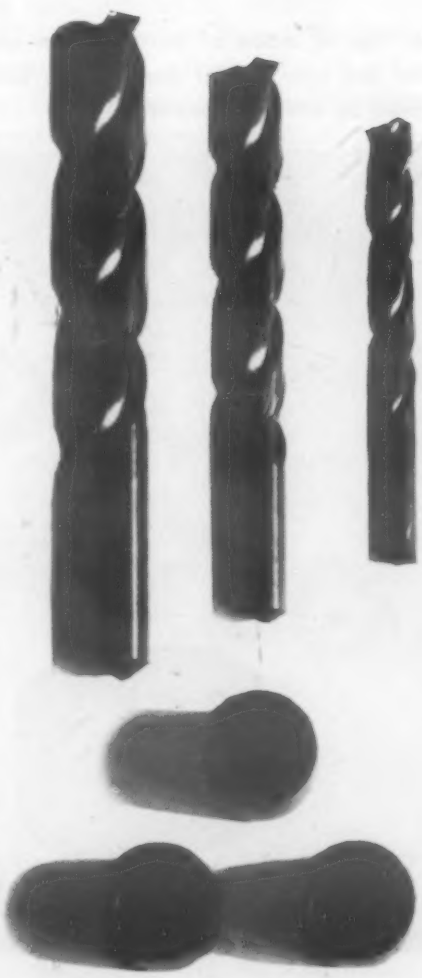
While not much specific data are available on the corrosion resistance of the oxide film, the corrosion resistance of steam treated surfaces after oil dipping is reported equal to that obtained with surfaces treated by chemical oxidizing processes and oil dipped. Parts such as bolts are quenched into a soluble oil solution after steam treatment.

Where parts are to be plated or given other surface finishing, the uniform, relatively clean surface from steam treatment results in shorter pickling times. One user reports that the time for pickling prior to plating for steam treated bolts is only one-sixth of that required when the bolts were tempered in an air atmosphere.

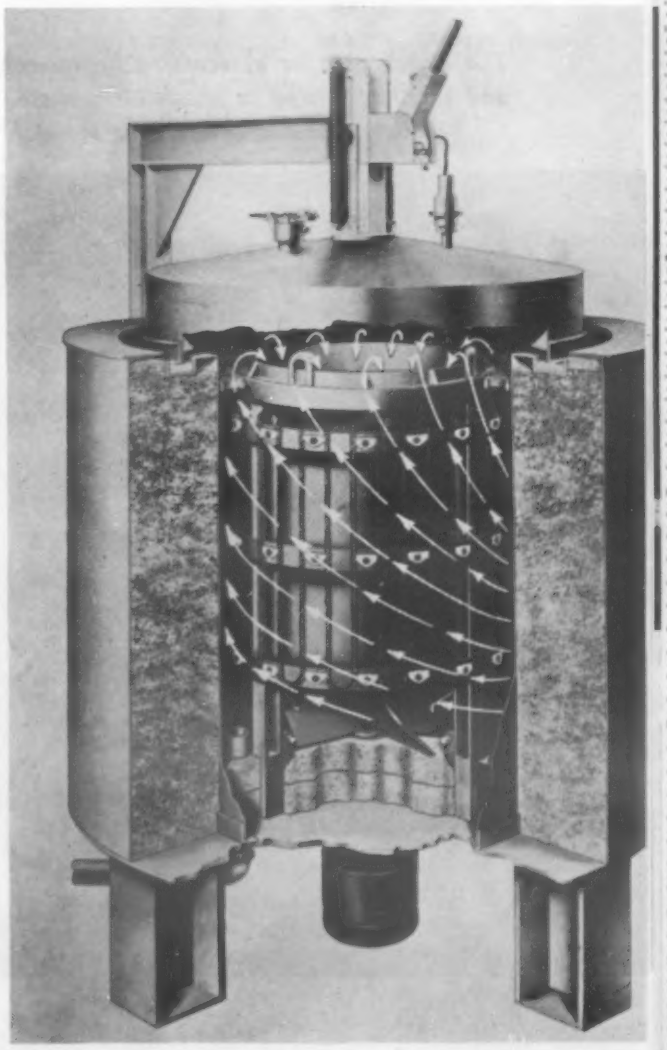
Over a period of several years tests have shown that tool life of high-speed cutting tools, such as twist drills, broaches, reamers and taps, can be significantly increased by the steam tempering method. The steam tempering treatment is the final step, and is applied after finish grinding. As yet, the complete reason for the increased tool life is not known. However, it is believed that the oxide film minimizes the tendency for particles of steel to weld onto the tool surface; also, the porous oxide surface is a better retainer of the cutting lubricant. While the beneficial results of steam treatment have been proven for tools used on ferrous metals, there are indications that the improvement in tools for cutting the softer nonferrous metals, such as aluminum, magnesium, brass and

A basket of milling cutters being lowered into the furnace for steam atmosphere heat treatment.

Typical parts heat treated in a steam atmosphere include twist drills, bolts, brass cups, and beryllium copper parts.



Cutaway view of specially designed batch-type electric furnace for steam atmosphere treatment of parts.



bronze, is not as great. However, in cutting these materials tool life is not generally a problem.

A typical case of steam tempering tools is that of twist drills made of high-speed tool steels of the 18-4-1 and the 8-4-2 types. The cycle consists of heating a batch of 200 to 1000 drills, weighing 75 to 500 lb., to 700 F and then purging with steam for ½ hr. at this temperature. The temperature is then raised to 1000 F and held for 20 min. After this, the work is removed, cooled in air, and dipped in light oil. These steam treated drills, when used for drilling heat treated alloy steel, average about 100% longer life than untreated drills.

Steam atmosphere treatment has also found use on iron powder parts for increasing hardness and wear and corrosion resistance. Because of the porous nature of metal powder compacts, the oxide not only forms on the surface but penetrates through the entire piece. Steam treated sintered iron parts which were impregnated with oil after treatment showed better corrosion resistance than conventional compacts on the bearing surfaces where alternate heating and cooling results in condensation of moisture. Also, the hard oxide surface provides better wearing-in properties, and as the original surface is worn away, the oxides in the pores become exposed to offer continued resistance to wear.

A substantial increase in over-all surface hardness of iron powder parts is obtained because the oxide fills the pores. For example, iron powder shock absorber pistons that were steam treated increased in hardness from 15 to 85 Rockwell B. At the same time, the yield point under compression was doubled.

The steam atmosphere process can also be used on cast iron parts to increase wear resistance. The hardness of the oxide coating and its ability to retain lubricants provides good wearing-in properties on bearing surfaces; this, in turn, results in a better fit.

Nonferrous Metals

The basic steps for steam atmosphere treatment of nonferrous materials are essentially the same as for ferrous metals; however, times and temperatures differ, depending on the particular metal being treated. Thus far, aluminum, brass and beryllium copper have been successfully treated.

A particularly interesting case is the use of a steam atmosphere for heat treating aluminum clutch arms that fit into Micromax recorders. The arm is made of 61 SO aluminum alloy. The final processing steps on this clutch arm involve a solution heat treatment at 970 F for ½ hr., followed by a water quench. The part then undergoes a final coining operation, after which it is given a low temperature age hardening treatment in air. Finally, the part is buffed to obtain the required bright surface finish. Formerly, the solution heat treatment was done in an air atmosphere causing a white matte appearance which required extensive buffing to remove and to obtain a bright finish. By solution heat treating the aluminum in a steam atmosphere using the same cycle, a light mottled gray finish is obtained which reduces considerably the buffing time. Where formerly parts were buffed at the rate of 50 per hr. per man, the rate has now increased to 84 per hr. per man, resulting in a cut in finishing costs of 40%.

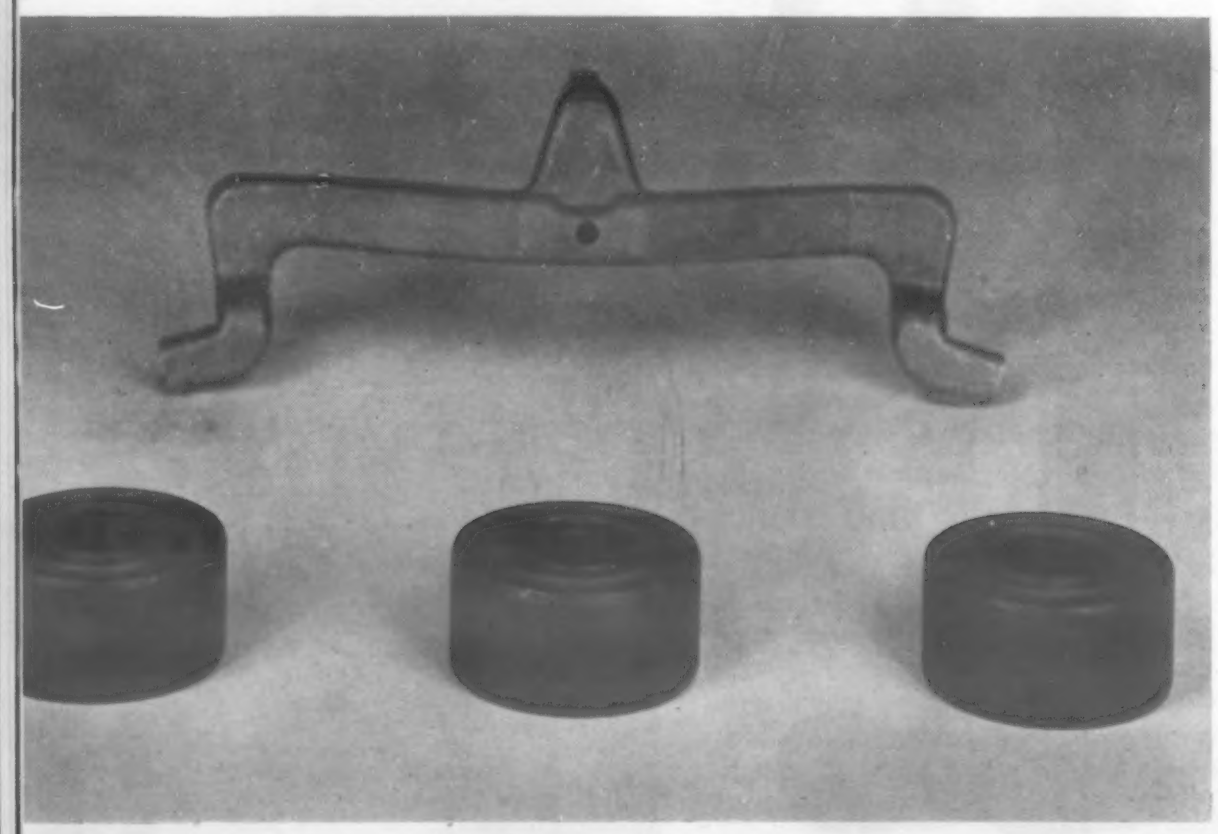
The use of a steam atmosphere for annealing or stress relieving brass with copper contents of 80% or less has proved to have advantages. It eliminates pickling between cold working operations and makes for easier cleaning prior to plating. A typical cycle for steam treating brass consists of purging at 600 F, then soaking for 45 min. at 900 F. For a work load weighing 1000 lb. the complete cycle requires 2¼ hr.

One manufacturer is now successfully using the steam atmosphere process for the stress-relief treatment of brass fittings for valves, regulators, and nozzles for oxygen and acetylene torches. He formerly performed this treatment in an air atmosphere, resulting in badly oxidized surfaces that had to be cleaned by a bright dipping operation involving a hot potash wash, an acid dip, a cold water dip, and a hot water rinse. By using the steam atmosphere process, the parts after heat treatment are only slightly dull in appearance and are considered to be satisfactory without the need of a bright dip. If pickling or other cleaning treatments are not used after the anneal, the oxide film that ordinarily forms is hard on the forming dies. By steam atmosphere annealing the surfaces are free of this unwanted hard oxide, resulting in increased life of tools and dies.

Finally, steam treatment has proved beneficial for precipitation hardening of beryllium copper parts, because it results in easier cleaning prior to plating. The soaking temperature for beryllium copper is 625 F, which is somewhat under the operating range previously considered useful for a steam atmosphere.

For description of steam treating method for large parts using conventional batch-type hearth furnaces with a special air-tight steam box inside the furnace chamber, see MATERIALS & METHODS, *Apr. 1949, p. 54* —*The Editors.*

The clutch arm for a recording instrument, shown at top, is made of an aluminum alloy and solution treated in steam atmosphere. At bottom are iron powder parts whose hardness and compressive strength are improved by steam treatment.



New Aluminum Extruding Alloy Used for Tubing and Architectural Applications

Excellent working properties, good corrosion resistance and improved finish are the outstanding characteristics of this aluminum alloy.

• AT THE END of World War II a new aluminum alloy intended for decorative extrusions was developed by the Aluminum Co. of America after many months of study of the metal in the laboratory and under service conditions. Although introduced with little fanfare, the material has since become a major peacetime aluminum alloy. It is finding ever increasing application, principally in the architectural field, where it is filling the place formerly held by the 53S composition, and in the extruding of lightweight tubing.

Decorative architectural shapes are frequently complicated in cross-sectional design, and are sometimes made hollow to save material and weight. The new alloy, designated 63S, has excellent working properties and permits more economical extruding of these elaborate forms. It also possesses good resistance to corrosion, another requisite of a material for decorative use in buildings. Finally, it can be given an anodic oxide finish without the slight discoloration or mottling that sometimes occurs with the 53S alloy.

The nominal composition of 63S is:

Silicon	0.4%
Magnesium	0.7%
Aluminum and normal impurities, balance	

The content of alloying elements has been lowered slightly from the values in 53S, for which the nominal composition was:

Silicon	0.7%
Magnesium	1.3%
Chromium	0.25%
Aluminum and normal impurities, balance	

Alloy 63S is used only for extrusions and tubing. Excellent extrudability, moderate strength, and good finish are its features. High-strength extrusions, such as are used for aircraft construction, will continue to use such alloys as 75S, 24S and 14S, where a high strength-weight ratio is obtained. The solution heat treatment of 63S is attended with excessive grain growth which results in undesirable appearance on strengthening. For this reason this process is not recommended.

When better strength is needed than the alloy possesses in the as-extruded condition, heat treating, consisting of artificial aging, can effect improvement. The ability to take a smooth anodic finish is not affected by heat treatment.

In addition to its use in the architectural field, tubing of 63S is finding application in portable irrigation systems. Here good corrosion resistance, good strength, and light weight are the factors determining its selection. For this purpose it is usually used in the fully aged condition.

Physical properties for 63S in the various tempers in which it is offered are shown in chart below.

The composition of the alloy will fall within the following ranges:

Silicon	0.2 to 0.6 %
Magnesium	0.45 to 0.85%
Iron	0.35 max.
Copper	0.10 max.
Zinc	0.10 max.
Chromium	0.10 max.
Titanium	0.10 max.
Other Elements, total	0.15 max.
Aluminum	balance

Some other properties of interest are:

Specific gravity	2.70
Weight per cu. ft.	0.098 lb.
Melting range	1140 to 1205 F
Electrical conductivity, % of standard copper	
F-temper	50%
T5-or T6-temper	55%
Thermal conductivity, at 25 C, c.g.s. units	
F-temper	0.46
T5-or T6-temper	0.50

	Tensile Str., Psi.	Yield Str., Psi.	Elong. % in 2 In.	Brinell, 500-Kg. Load, 10-Mm. Ball	Shear Str., Psi.
As Extruded (F-Temper)					
Typical	22,000	13,000	20	42	14,000
Specified	17,000	10,000	10	—	—
Artificially Aged (T5-Temper)					
Typical	30,000	25,000	12	65	18,000
Specified	22,000	16,000	8	—	—
Solution Heat-Treated and Artificially Aged* (T6-Temper)					
Typical	35,000	30,000	12	73	22,000
Specified, to ⅛-In. Thick	32,000	25,000	8	—	—
⅛ to ½-In.	32,000	25,000	10	—	—

** By combining the solution heat treatment with the extrusion process, grain growth is avoided.*

Metal Coatings Improve Solder Flow on Steel and Brass

by **DAVID WALLACE,** Metallurgist, Materials Laboratory, Sperry Gyroscope Co.

Experience and tests with a number of coatings show that plated lead-tin alloy provides best solderability with rosin flux.

• MANY SOFT SOLDER JOINTS in electrical assemblies, and particularly in radio equipment, require the use of flux which is electrically nonconductive and which does not promote corrosion. These requirements are usually met by specifying the use of rosin flux. Although there are other fluxes which are claimed to be better than rosin in meeting the above requirements, carefully controlled tests in the laboratory have not substantiated such claims. While there are organic fluxes which decompose on heating so that the residue is noncorrosive and electrically nonconductive, it is difficult to be sure that the original organic salt has been completely decomposed during soldering. Many of these fluxes easily escape from the local area being soldered by capillary flow into the insulation and to other unheated areas and remain there actively corroding the metals they contact.

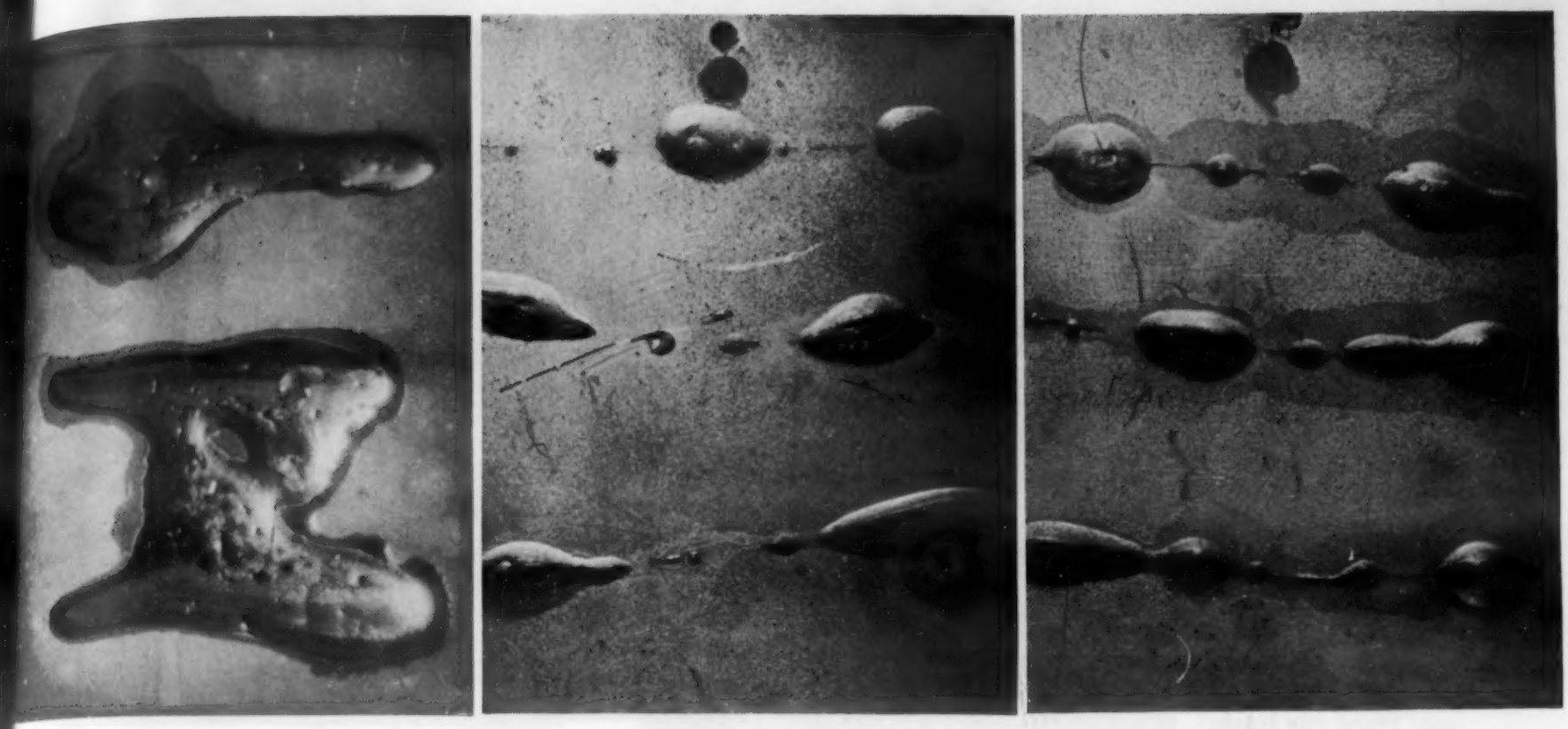
Other so-called noncorrosive fluxes include additions of chemically active organic salts in rosin to increase the activity of the rosin flux, but their effectiveness is questionable when present in such small quantities as to meet the requirements of being a noncorrosive and electrically nonconductive flux. On the other hand, sufficiently large additions of active chemicals to rosin alter the character of the flux residue so that it is no longer electrically nonconductive or noncorrosive, especially under conditions of high humidity at about 95 F. Therefore, the conservative practice of using pure rosin as a flux on all electrical joints is necessary, particularly where the joints cannot be washed to remove flux residues and on equipment where failure of a soldered joint is of critical importance.

The adoption of rosin as a standard flux for practically all electrical soldering has certain problems associated with it which have been the subject of study and investigation at Sperry Gyroscope Co. during the past few years. The main problem has been that parts, such as tin-plated brass terminal lugs, after storage for periods from three months to a year, become difficult to solder with rosin flux. These terminal lugs are plated with tin from an acid-tin bath in order to promote solder flow and permit the use of rosin. However, it was found that after periods of one to three months of storage the effectiveness of the tin coating in promoting solder flow was nil. This phenomenon is attributed to the formation of an oxide film on the surface of the tin coating which is not readily dissolved by rosin flux.

Various means have been attempted to overcome this difficulty. For example, the plated tin coating was fused in molten wax at 500 F and some improvement in solderability was obtained sufficient to warrant the fusion of all tin coatings where soldering was required. The improvement in solderability of the fused tin coating can be attributed to the decrease in the rate of oxide film formation. However, it was far from good enough, and other solutions to the problem of increasing solderability were sought.

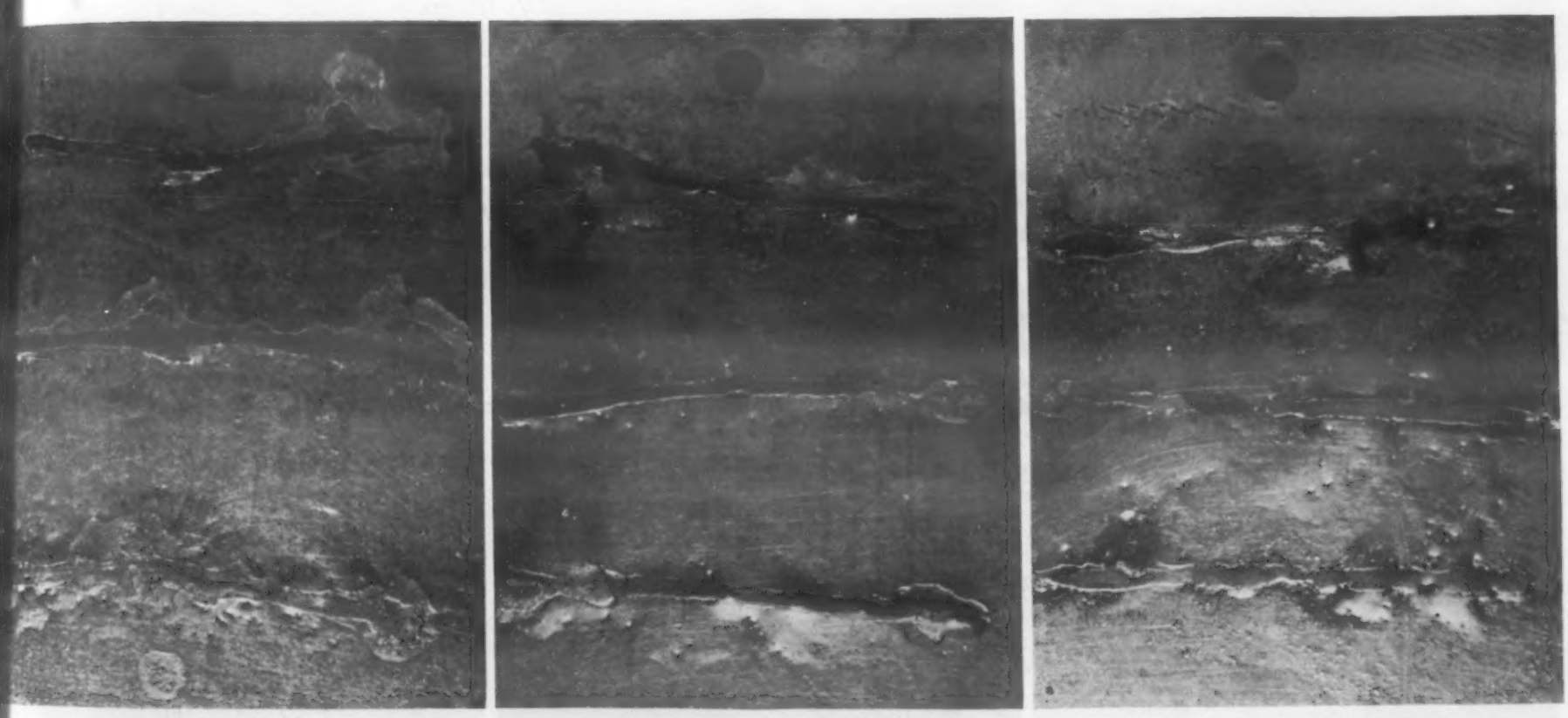
Hot-Dipped Solder Coating

Further consideration of the problem led to the coating of parts with a hot-dipped solder coating of a lead-tin alloy. It was felt that if the coat-



Immediately after plating. *6 months after plating.* *9 months after plating.*

Fig. 1—Spread of solder on brass panels electroplated with pure tin.

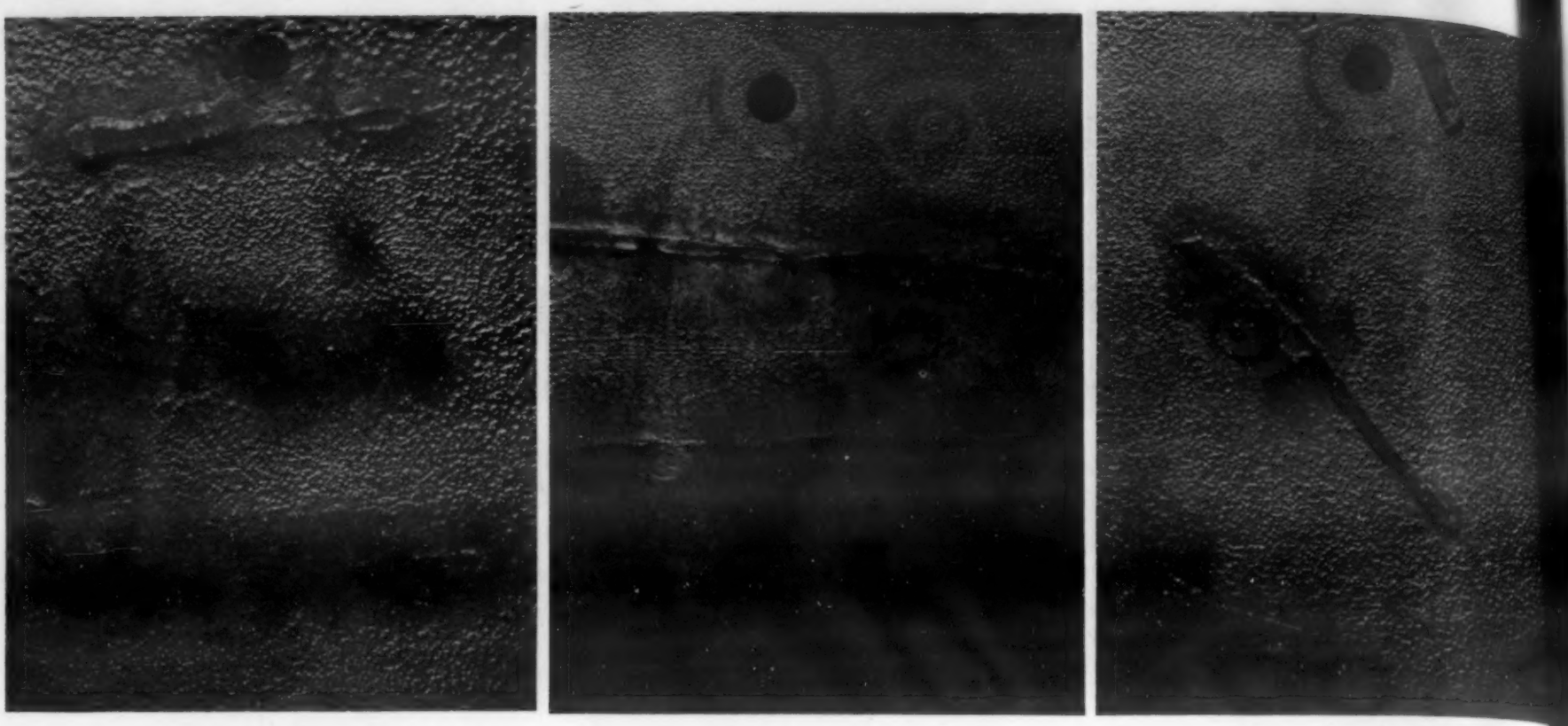


Immediately after coating. *6 months after coating.* *9 months after coating.*

Fig. 2—Spread of solder on brass panels coated with hot dipped solder.

ing melted at about the same temperature as the joining solder, interfering oxide films might be easily broken up and a well filled joint would result. Soldering tests conducted on hot-dipped coatings after one year of storage showed solderability as good as the day they were applied. By the same token, electroplated pure tin should also be suitable if the coating is melted during soldering. Unfortunately, pure tin coatings do not behave in this manner and the reasons are not definitely known; they may be related to differences in the character of the oxide, the difference in melting temperatures of pure tin and solder, and the higher surface tension of pure tin coatings compared to that of solder coatings.

The hot-dipped solder coating is applied by first dipping the parts in a water solution of a zinc chloride type flux; immersing in a molten solder bath; transferring to a centrifuge to spin off the excess solder. The parts are then quenched in clean cold water to remove flux residues. The parts thus cooled retain a bright surface free of oxide films, which might form if they cooled slowly. The thickness of the coatings vary from 0.0003 to 0.010 in., depending



Immediately after plating. *6 months after plating.* *9 months after plating.*

Fig. 3—Spread of solder on brass panels electroplated with 60-40 (approx.) alloy.

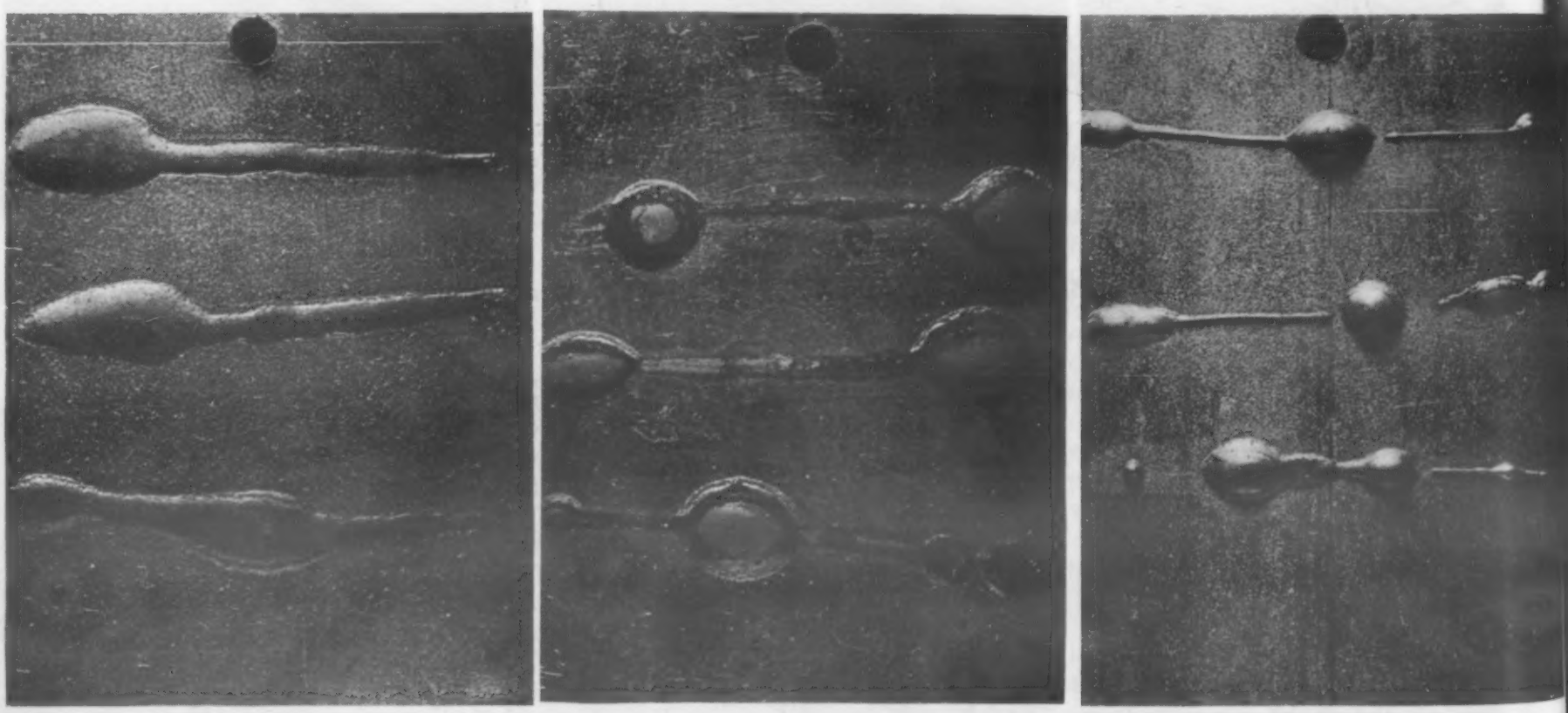
on the shape of the part. Although this variation was not objectionable for some parts, it seriously interfered when parts were used as inserts in molds for plastic injection. The tolerances of the molds were such that closer control on the thickness of the coating was required and, therefore, it was necessary to return to the use of electroplated tin, which is more easily controlled. However, the problem of poor solderability of electroplated tin coatings after a short period of storage remained.

Plated Lead-Tin Coating

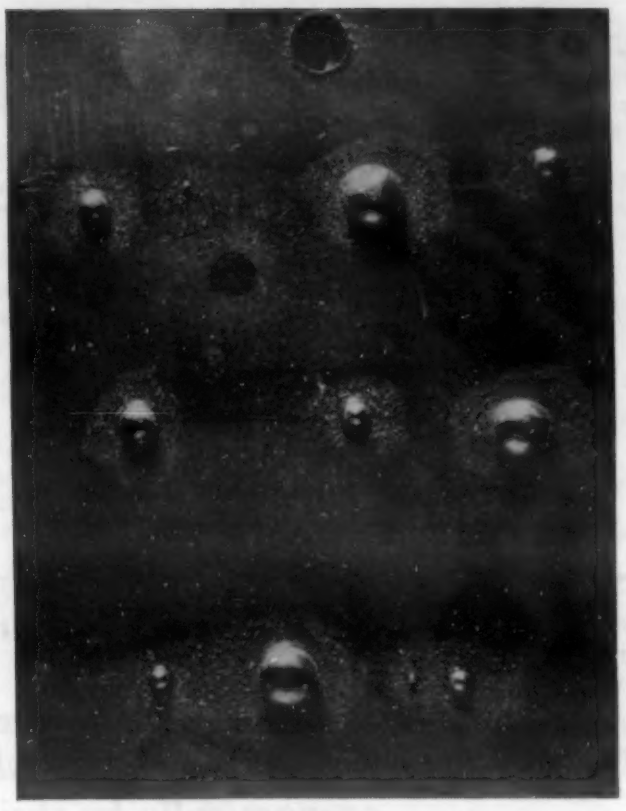
Since it was necessary to plate a solderable coating to obtain good dimensional control and since the lead-tin alloys had excellent solderability even after considerable storage

Fig. 4—Spread of solder on brass panels electroplated with cadmium.

Immediately after plating. *6 months after plating.* *9 months after plating.*



Immediately after plating.



6 months after plating.

Fig. 5—Spread of solder on brass panels electroplated with bright alloy.

time, it seemed logical to assume that the ideal solution to the problem would be to plate lead-tin alloys instead of applying the coating by hot-dipping. Therefore, when a plating bath became commercially available which could plate lead-tin alloys, we initiated an investigation of the soldering properties of the coating. Panels of steel and brass were submitted to the General Chemical Co., who had developed the bath, to plate with approximately the eutectic composition of lead and tin about 0.0002 in. thick.

In addition, we plated panels of steel and brass with other metals to compare the solderability of the plated lead-tin with that of other metals as a function of storage time. In selecting the other metals for this comparison, only those which could be soldered with rosin flux and which had some promise of low rate of oxidation or tarnish were used. Although freshly plated silver and copper are often considered excellent coatings to promote solderability, their rate of tarnish or oxidation is so rapid that they were not included. The following plating metals were used:

Pure tin, as plated—0.0002 to 0.0003 in. thick.

Pure tin, plated and then fused—0.0002 to 0.0003 in. thick.

Cadmium, as plated—0.0002 to 0.0003 in. thick.

Bright alloy, electroplated (developed by Hanson-Van Winkle-Munning).

Hot solder dip (60-40 solder).

The test procedure used for evaluating the ability of the metal coating to promote soldering was as follows: (1) A 1-in. length of rosin core 60-40 solder was placed on a panel. (2) The panel was placed on an electrically heated hot plate whose temperature was fixed at 420 F. (3) After the solder melted, 15 sec. were permitted to elapse before the panel was removed from the hot plate. The ability of the coating to promote soldering was then evaluated on the basis of the extent to which the solder had spread.

It should be emphasized that this test is only intended to detect gross differences between the coatings tested. Accordingly, the evaluation of solderability is qualitative and is based on the extent to which the coating influences the molten solder to retain a spherical shape on melting. A rating of "excellent" indicates that the coating promoted solder flow to the extent of producing a fairly flat layer of solder on the coating. A rating of "poor" indicates that the coating has promoted practically no spread of the solder and possibly there is no adhesion of the solder to the coating upon solidification. In the accompanying table are the results obtained using the above rating procedure, and evaluating solderability of the coating immediately after plating, with the tests repeated on some panels exposed to the atmosphere for six months and others for 9 months.

It is evident from the results that the plated lead-tin alloy has excellent solderability for at least a 9-month storage period and, therefore, assures excellent solderability with rosin flux over a period of at least 9 months.

Coating	Solderability		
	Immediately After Plating	6 Months After Plating	9 Months After Plating
Hot Dipped Solder	Excellent	Excellent	Excellent
Plated Tin	Excellent	Poor	Poor
Plated Lead-Tin Alloy	Excellent	Excellent	Excellent
Cadmium	Fair	Poor	Poor
Bright Alloy	Poor	Poor	Poor

Acknowledgment

The author wishes to express his appreciation to Mr. Carl Abeles for the photographic work shown in this article.

Assembling Metal Parts by Shrink Fitting

by C. DESCHARS,
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● THERE ARE THREE simple methods of assembling metal parts by fitting: pressure fit, expansion fit, and contraction fit. Pressure fitting is achieved by exercising a certain amount of pressure along the axis of the assembly for the purpose of introducing the male part into the female part. The pressure is usually supplied by a press of sufficient capacity. This process has the disadvantage of affecting the surface of the parts in contact (milling phenomena), but maintains their structure and their physical-chemical composition. It must be used very cautiously when one of the assembled parts shows tendencies of brittleness.

Liquid nitrogen used for shrink fitting flows like water and has a boiling point of −320 F. Thin film of air prevents burning of skin.

Both ferrous and nonferrous mechanical parts often can be assembled more simply, quickly and economically by shrink fitting, using liquid nitrogen as the cooling medium.

Fitting by expansion is obtained by heating the female part. The diameter of the female part increases and it becomes possible, at a certain temperature, to introduce the male part into the opening. On cooling, the female part contracts and provides the necessary grip. In order to use this process it is necessary that there be no distortion caused by heating the female part.

Fitting by contraction or shrinking, which is the subject of this article, is obtained by sufficiently cooling the male part so that it penetrates without any difficulty into its location. Subsequently, the part warms up to room temperature and regains its original dimensions by expansion and firmly compresses the surfaces, thereby obtaining the necessary contact pressure. The difference in the dimensions of the two parts causing the contact pressure is called grip.

In some applications it may be convenient to combine these three processes or to use them simultaneously. For example, it may be possible to heat the female part and cool the male part. It is also possible, if necessary, to use a press to obtain the fitting.

Principle of the Process

In shrink fitting the cooling is achieved by immersing the male part in a cooling mixture causing sharp decrease in temperature; to obtain suitable grip for this purpose liquid nitrogen is very often used. The boiling point of the liquid nitrogen is —320.3 F.

Liquid nitrogen is produced industrially by distillation of liquid air obtained by cooling and expanding atmospheric air. The liquid air is transformed in fractionative columns into a liquid with a high oxygen content called rich liquid and into a liquid with a high nitrogen content called poor liquid. The rich liquid bursts into flame in the presence of greasy parts. With the poor liquid—liquid nitrogen—this danger does not exist; therefore, liquid nitrogen is generally used. In addition, the boiling point, —320 F is lower than that of rich liquid (oxygen boils at —295.6 F) and, therefore, permits of quicker cooling (6% gain).

Liquid gases are shipped in special containers, similar to Dewar flasks. These consist of an internal metallic container of spherical shape with a double wall and intermediate vacuum. The liquid is, therefore, well protected from the exterior heat radiating from the wall; the only possible evaporation occurs through the free surface in contact with the atmosphere. This evaporation is kept to a minimum by means of a long narrow neck at the top of the container. Special containers have been made for immersion of parts to be fitted. They have large necks which permit the immersion of large parts. These containers are of similar construction to those mentioned above.

Containers used for shipment of the liquid or for immersion must never be closed. The evaporation of one liter of liquid nitrogen produces approximately 800 liters of gaseous nitrogen at normal temperature; should this evaporation occur in a closed container, the internal pressure could then reach 11,200 psi, if the container were sufficiently strong. In a closed container, the cap would then be violently blown off

by the increasing pressure. The metallic lid closing the immersion containers does not constitute a sealed cap but simply protects the container against the introduction of foreign matter and acts as a screen which reduces the evaporation of the liquid in contact with the surrounding air.

The handling of liquid nitrogen is quite simple: it flows like water and is of the same color and density. It boils with heavy white fumes which are not actually liquid nitrogen vapor but are produced by the instantaneous condensation of the impurities of the atmosphere. Water vapor and carbonic gas when in contact with gaseous nitrogen at very low temperature are condensed.

When the part to be fitted is immersed in the liquid nitrogen, the boiling is first relatively slow because the gaseous layer which surrounds the part prevents its rapid cooling. Finally, the part becomes sufficiently cold for the liquid to wet it, and then a considerable increase in boiling is immediately observed. This ceases when the temperature of the immersed part is equal to that of the liquid.

Occasional contact of the skin with liquid nitrogen is generally harmless; however, this is not so if the operator touches metallic parts cooled by immersion. The gaseous layer no longer protects the skin and serious burns may occur. It is, therefore, necessary to immerse the parts to be fitted by means of a special jig which enables them to be handled without direct contact, or at least using gloves. The use of a jig also permits quick centering and introduction of the part into the opening. These conditions are necessary for the success of the operation, because the cooled parts warm up again very quickly.

The consumption of liquid nitrogen varies according to the heat given by the immersed part. Table I gives data on consumption for a number of metals and alloys. When specific weight and heat of an alloy are not known, and when accurate figures are needed, it is safer to calculate them using the mixture law. It is for this reason that figures for zinc, tin, manganese and silicon, which will always be used in alloys for the applications of shrink fitting, are included in Table I.

The amount of contraction of the metallic part, cooled by the liquid nitrogen, is given in Table II. The inner part, when cooled in liquid nitrogen, should easily slip into the outer part. The contraction determined by Table II must allow the fit to take place. Table III gives tolerances for sliding fit.

Table I—Consumption of Liquid Nitrogen in Shrink Fitting Various Metals

Material	Density Lb./Cu. In.	Average Specific Heat Between +60 and —320 F	Quantity of Liquid Nitrogen in Liters to Cool 1 Lb. of Metal
Steel	0.285	0.110	0.249
Aluminum	0.094	0.175	0.396
Bronze	0.323	0.081	0.183
Copper	0.322	0.079	0.179
Tin	0.264	0.086	0.194
Iron	0.284	0.085	0.192
Cast Iron	0.260	0.120	0.271
Brass	0.305	0.081	0.183
Magnesium	0.063	0.208	0.471
Manganese	0.280	0.093	0.210
Nickel	0.317	0.087	0.197
Silicon	0.080	0.118	0.267
Zinc	0.258	0.084	0.190

Table II—Contraction Data on Various Materials

Material	Linear Coefficient of Expansion Between +60 and —320 F	Linear Contraction of 1 In. of Length Between +60 and —320 F
Bronze	8.9×10^{-6}	0.0034
Copper	7.9×10^{-6}	0.0030
Tin	12.1×10^{-6}	0.0046
Iron	5.0×10^{-6}	0.0019
Cast Iron	4.7×10^{-6}	0.0018
Brass	8.9×10^{-6}	0.0034
Magnesium	11.8×10^{-6}	0.0045
Manganese	8.7×10^{-6}	0.0033
Nickel	5.5×10^{-6}	0.0021
Silicon	0.95×10^{-6}	0.00036
Zinc	14.5×10^{-6}	0.0055
High-Speed Steel—18 Ni, 4 Cr, 1% Va	5.0×10^{-6}	0.0019
High-Speed Steel—6 Ni, 5 Mo, 4 Cr, 2% Va	5.3×10^{-6}	0.0020
High-Speed Steel—18 Ni, 4 Cr, 2 Va, 9% Co	4.5×10^{-6}	0.0017
High-Speed Steel—5 Ni, 4 Mo, 4 Cr, 4% Va	5.8×10^{-6}	0.0022
Tool Steel—1.10% C	5.0×10^{-6}	0.0019
Tool Steel—0.90 C, 1.2 Mg, 0.5 Cr, 0.5% Ni	5.3×10^{-6}	0.0020
Tool Steel—0.5 C, 0.9 Cr, 1.25% Ni	4.7×10^{-6}	0.0018
Tool Steel—2.25 C, 12 Cr, 1% Mo	5.3×10^{-6}	0.0020
Chromium Vanadium Steel (SAE 6150)	5.8×10^{-6}	0.0022
Machine Steel (SAE 1020)	5.8×10^{-6}	0.0022
Stainless Steel 18 Cr, 8% Ni	7.4×10^{-6}	0.0028
Aluminum (2S)	8.2×10^{-6}	0.0031
Aluminum (24 S-T)	9.3×10^{-6}	0.0040
Invar (36)	1.3×10^{-6}	0.0005
Cast Alloy—20 Co, 8 Ni, 7 Mo, 5 Cr, 2 Va, 0.7 C, 0.7% B, Balance Fe	3.7×10^{-6}	0.0014
Cast Alloy—44 Co, 17 Ni, 33 Cr, 2.25 C, 2% Fe	4.5×10^{-6}	0.0017
Carboloy (Grade 44A)	1.8×10^{-6}	0.0007
Monel Metal	6.6×10^{-6}	0.0025

Applications of Shrink Fitting

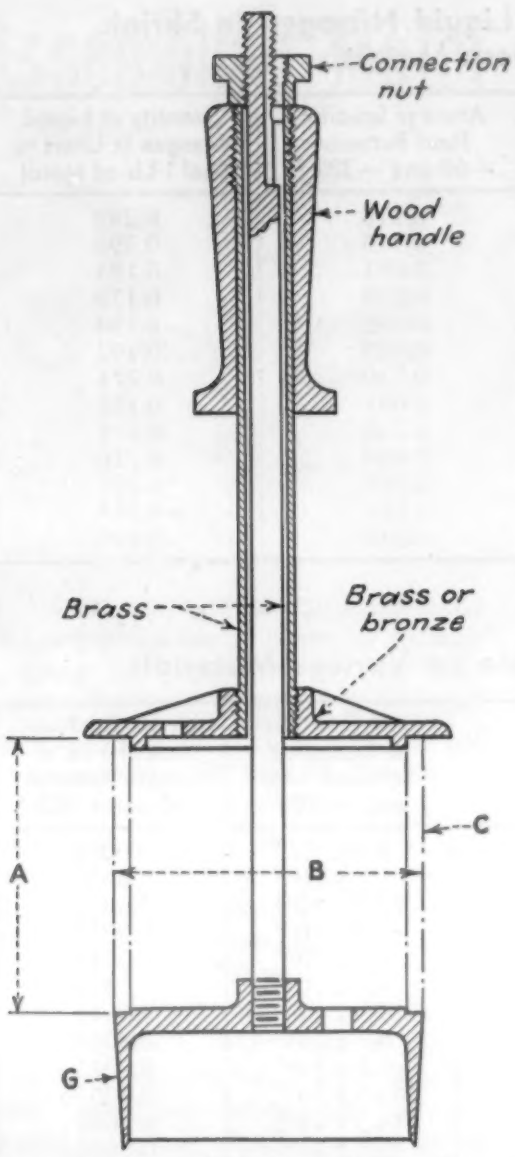
The process of shrink fitting has gained the approval of many industries. The few examples described below show some actual applications of this method of assembling.

Sleeve for Car Engine—This application of fitting by shrinking is normally used in the automobile industry. Fitting sleeves in engine cylinders formerly was done with a press or by heating the engine block.

When the fitting was performed by the press, many parts were lost due to the fact that the nitrided cast iron sleeves are of small thickness (0.8 in.) and rather brittle. Furthermore, it was not possible to get a

Table III—Tolerances for Sliding Fit

Diameter of the Fitting In.	Total Tolerance of Sliding Fit—In.	
	Close	Moderate
0.5	0.0005	0.0009
1.0	0.0008	0.0017
3.5	0.0016	0.0035
6.0	0.0025	0.005



Brass jig for shrink fitting sleeves in engine cylinders. The sleeve is indicated at "C."

powerful grip. The fitting made by heating the engine block to 570 F in an oil bath was long and expensive because of the size of the block.

Fitting by immersion of the sleeve in liquid nitrogen was found simple, quick, and economical. Because the sleeve is small in size, it was not necessary to evaporate large quantities of liquid to get the low temperatures required for the fitting. The first tests proved that a jig was necessary for the success of the operation. This jig is made of brass because it is less brittle than others at low temperatures. The sleeve is fixed between two trays so it can easily be handled during and after immersion by means of the wooden holder. After the fitting has taken place, the bottom tray is easily unscrewed and is ready to be used once more.

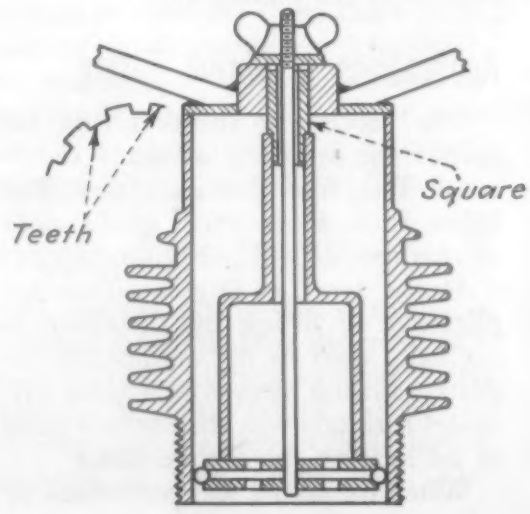
The sleeve had the following dimensions: dia., 2.5 in.; thickness, 0.8 in.; height, 3.8 in. The grip had to be 0.0016 in. The consumption of liquid nitrogen was 1 liter for a 6-cylinder engine. This corresponds to the theoretical figures of Table I if the liquid necessary to cool the immersion container and the jigs is included. The total time (placing the sleeve on the jig, cooling, fitting and dismantling) was 8 min. per engine as compared to 16 min. by the former method.

The micrographic examination of the nitrided cast iron after immersion and return to room temperature did not show any apparent change in the structure.

Sleeves for Cylinders on Hydraulic Presses—Shrink fitting was used successfully in building hydraulic presses that required sleeves in four cylinders. The fitting was made by contraction of the sleeves in liquid nitrogen, because heating of the block could have released foundry stresses, thereby causing deformations. Furthermore, it would have been necessary to use intense heating methods. The sleeves had the following dimensions: O.D., 18.5 in.; I.D., 17.7 in.; height, 19.7 in.; weight, 128 lb. The sleeves were suspended from a horizontal bar by means of three lifting rings. A shoulder at the bottom stopped the part in the right position. The total time from the beginning of the the cooling of the immersion container to the end of the cooling of the fourth sleeve was 25 min. The consumption was 150 liters of liquid nitrogen. The theoretical consumption is 105 liters. The difference between these two figures was caused by the cooling of the immersion container and the liquid left at the end of the operation.

Seating of Valves for Car Engines—The use of inserted valve seats in modern engines has brought up the difficult problem of keeping these parts tight in their location. They are of small dimensions, exposed to high temperatures, so that they can hardly be fixed by the usual mechanical methods. Pressure fit does not give good results for two reasons: first, difficulty of centering the seat due to its small height; and second, the maximum grip (0.0016 in.) available with this process has been found insufficient.

Jig for fitting of cylinder of airplane engine with cooling fins.



Fitting by shrinking allows good centering, and a solid grip (from 0.004 to 0.006 in.) can be obtained. In France it is used by many automotive firms. For car engines, the general tendency is to use insert valve seats of chromium-molybdenum cast iron with cast iron head engines and bronze seats with aluminum head engines. The seats can be smooth or threaded. The jig used to handle the smooth seats is always made of a brass rod with a wooden handle at one end and a brass base at the other end, with a slitted ring underneath used as a spring. The seat is forced around the ring. The assembly being elastic can easily be taken off after fitting. The brass rod extends under the base supporting the valve seat insert to allow an easy centering. The assembly is automatically guided and the valve seat insert is quickly laid into its position. The laying of 120 exhaust valves in 30 blocks required only 30 min. and used approximately 3 liters of liquid nitrogen, including the cooling of the immersion container.

Breaking tests made with smooth seats of 1.6-in. dia. shrink fitted in cast iron blocks gave the following results:

Grip	*Breaking Stress*
0.0067 in.	2,540 lb.
0.0051 in.	1,900 lb.

At the Ford plant a special machine was designed for fitting valve seat inserts. This machine consists of two distinct parts, the refrigerator and the mechanism for fitting. The parts are cooled in the refrigerator by means of liquid nitrogen and then are delivered eight at a time to the machine. The machine itself is located on the assembly line. When the engine arrives it lowers a dog which rises abruptly after the block has passed. The latter is then taken back against the dog. It is also fixed on each side by guided rollers.

Eight ducts coming from the refrigerator arrive in front of the eight valve seat locators. The seats are held at the end of the ducts by movable dogs. These dogs are withdrawn when eight automatic pistons insert the seats inside the valve seat locator. The pressure of the piston lasts approximately 5 sec. At the end of the run the strike of a spring produces

a shock which makes a close contact between the seat and the valve seat locator.

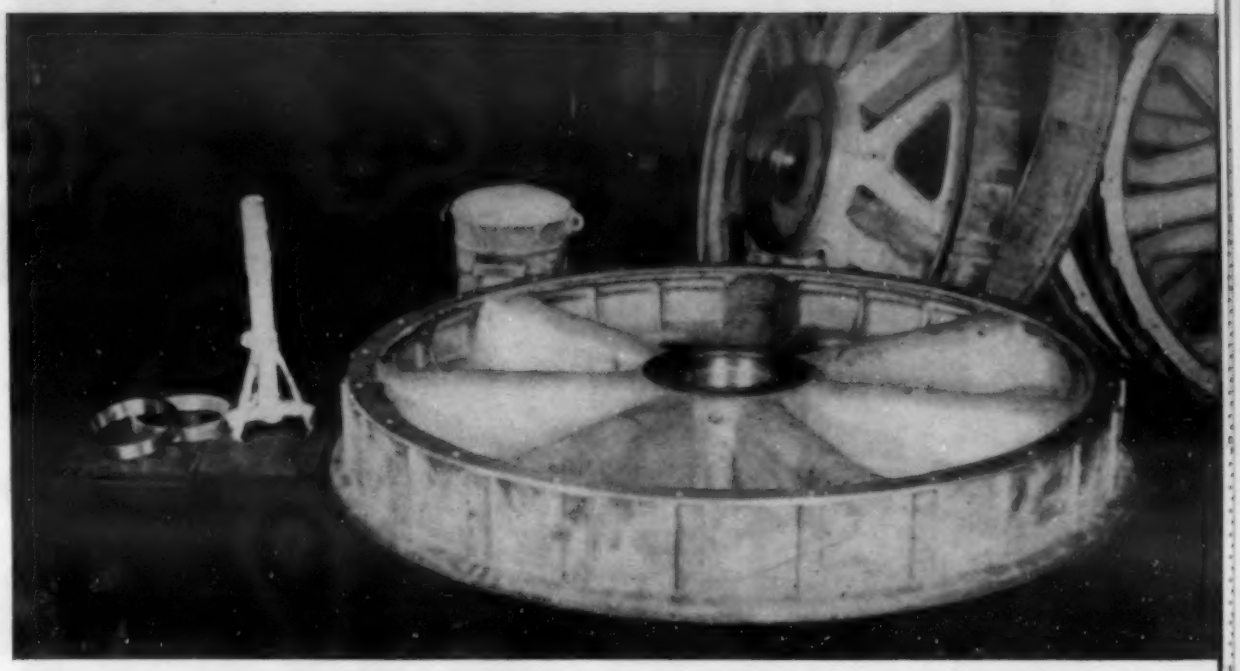
Fitting of Air-Cooled Cylinder for an Airplane Engine — The engine heads are made of alloyed aluminum and the cylinders of steel. The two parts are screwed with grip. Before using liquid nitrogen, the head engine was heated in a bath up to 750 F. The cylinder was then screwed mechanically in the head engine because the cooling was too fast to allow it to be done by hand (24 revolutions). At the end of the operation there was a shock due to the inertia of the machine. Tensions occurred which sometimes provoked the fracture of the engine head immediately or in operation, because the alloyed aluminum is very brittle at the temperature of 750 F.

Tests showed that the final grip was only 0.008 in., compared to a theoretical value of 0.012 in., because permanent deformations occurred in the engine head. As this final grip was practically large enough, it was adopted for the process of fitting by shrinking.

When the parts were cooled with liquid nitrogen it was not possible to get the grip of 0.008 in., so the compound process was used. The method involves heating the engine head up to 360 F and cooling the cylinder. To immerse the cylinder in the liquid nitrogen container, a special jig is used. The cylinder is held on the jig by the friction of a leather ring squeezed, more or less, by the operator between two trays. This device makes it easy to remove the fitting without dismantling it. Furthermore, the tightness of the leather ring has the advantage of keeping a supply of liquid nitrogen inside the threaded parts, which makes it easier to screw them. The cylinder is driven by means of teeth on the part and on the jig. The head engine is provided, beside the cylinder, with two valve seat inserts and three spark plug holders, all of them seated after having been cooled in liquid nitrogen. For these parts the grip is 0.004 in.

The consumption of liquid nitrogen for six operations (cylinder, two valve seat inserts, three spark plug holders) is three liters, and the approximate time, around 9 min.

Fitting of Ball Bearing Rings in Aluminum Wheels—The operation consists of fixing the outside rings of steel bearings whose diameters are 5.5 in. with a grip of 0.0016 in. The jig has three movable claws. It permits easy handling of the parts and can be taken off by the top after



Shrink fitting permits easy assembly of ball bearing rings in aluminum wheels. Rings and special jig are shown at left.

fitting has been achieved.

Fitting of an Axle Spindle of a Locomotive Crank Shaft—This operation consists of replacing a worn out axle spindle. The axle is normally built by expanding the flanges at 750 F. It was not possible to make the repair using this process because by heating the flanges the other parts of the axle could have moved. The solution adopted was to heat the flanges at a temperature of 212 F, and cool the axle spindle with liquid nitrogen. The grip adopted was around 0.022 in. The operation was performed as follows: the old axle spindle was partially machined off, then forced out with a press. To rebore it in good condition, four distance-pieces were placed and arc welded on the flanges. Heating of the flanges took 25 min. with two fuel burners, (consumption around 100 lb. of fuel). It took 26 min. to have the temperature equalized. The axle spindle remained in the liquid nitrogen container for 33 min. The consumption of liquid was 70 liters. The expansion of the bearing was 0.008 in. and the contraction of the axle spindle was 0.016 in.

The fitting of the axle spindle took place without any difficulty in 2 min. The grip started 4 min. after. At that moment the distance-pieces were flame cut to allow the free expansion of the axle spindle. To hold the flanges when the distance-pieces were cut, spacers had been laid previously between the flanges. Another spacer was used to stop the axle spindle at the end of the fitting. The axles which have been reclaimed by shrink fit are now in operation and have been found to be quite satisfactory in every way.

Reclamation of Crank Shafts of Presses—Shrink fitting was used successfully for the reclamation of a two-crank-wrist shaft of a press making side frames in a big automobile plant. This cumbersome shaft was 15 to 18 ft. long. It was broken in the middle of one of the crank wrists 19.7 in. in dia. It was decided to repair it by arc welding, and details of the repair method are shown in the accompanying sketch. First, the broken parts were fitted together and held with auxiliary steel rods arc welded on the crank. The axle of the crank wrist was then bored at 7.1 in. and a steel core 7.1 in. in dia. with a grip of 0.008 in. was fitted into the hole. The break in the crank wrist was then arc welded and the auxiliary rods were removed.

To check the dimensions of the boring and to make a test to find out how the operation would take place, a false steel core was first machined to allow it to pass in the hole without play. The dimension of the real steel core was only fixed after this test.

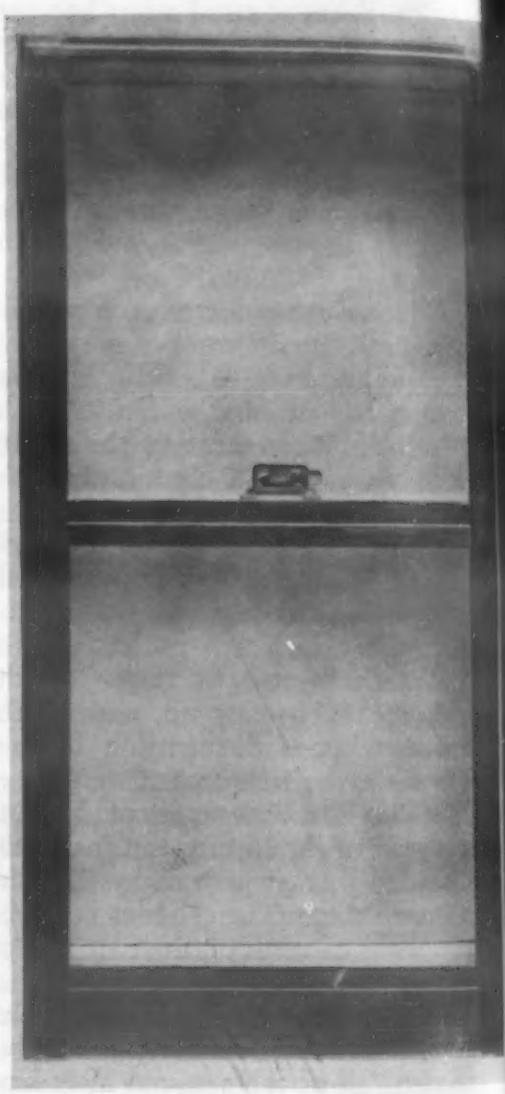
The fitting of the core was made by cooling it with liquid nitrogen. The immersion lasted 35 min., the consumption of liquid being 200 liters. The core was lifted with a chain hoist suspended from the travelling crane of the work shop. The crank shaft was placed vertically, the master-gear laying on the ground. The core taken out of the immersion container was brought over the crank wrist. It was then lowered down in its location until a dog stopped it at the right position. The operation took place in 15 sec. without any difficulty.

Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .

WELDED ALUMINUM CANS

Faced with the problem of producing 25,000 five-gallon aluminum cans a week over a period of ten months, the E. S. MacDonald Co. of Montreal used two General Electric Type WP Inert-Arc welders to facilitate production. The cans, designed for transporting acid, were constructed of type 57-SH aluminum, 0.032 in. thick. A welding speed of about 26 in. per min. was maintained, using 5 liters of argon gas per min. at approximately 60 amp. Tungsten electrodes, 3/32 in. in dia., were used.

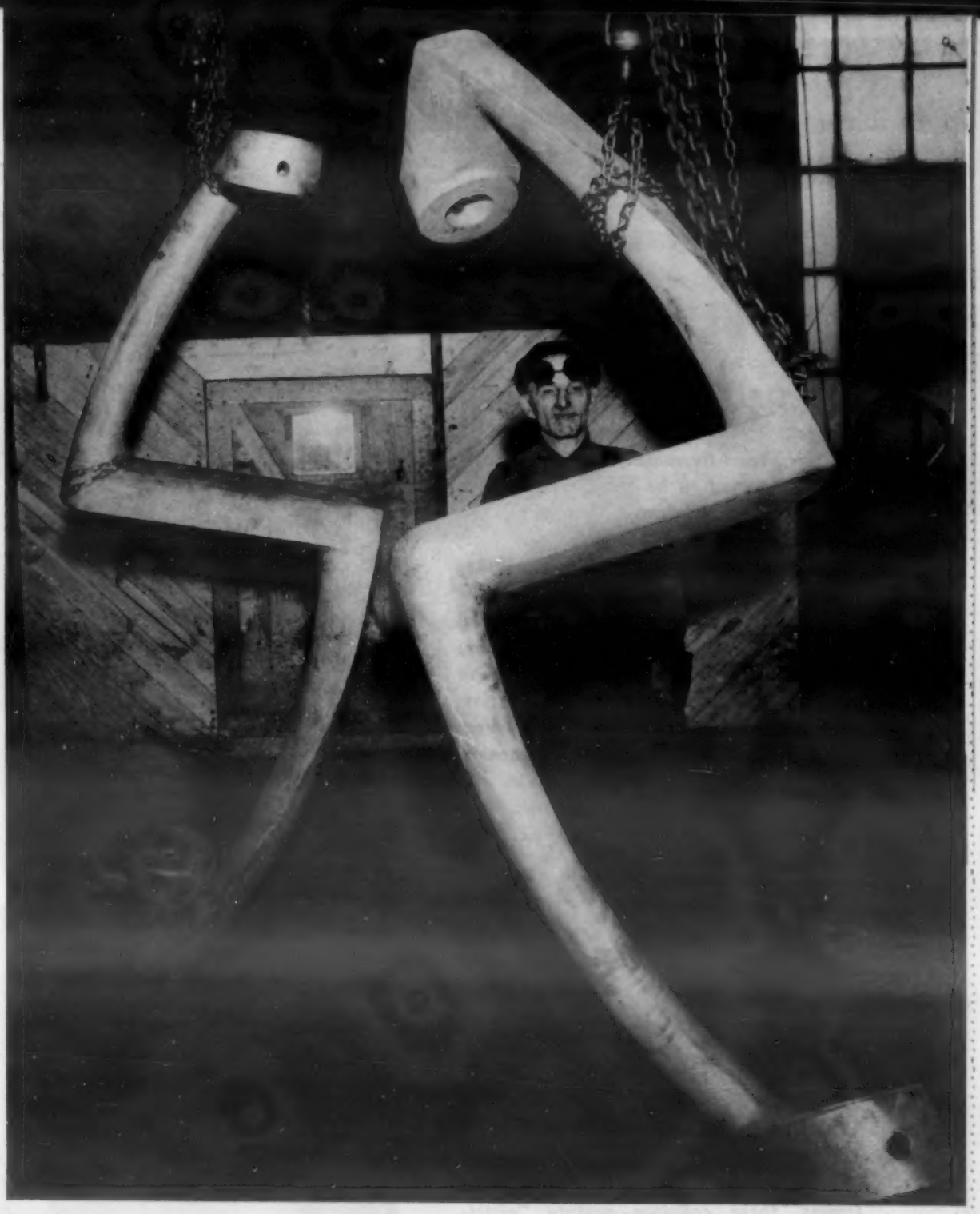


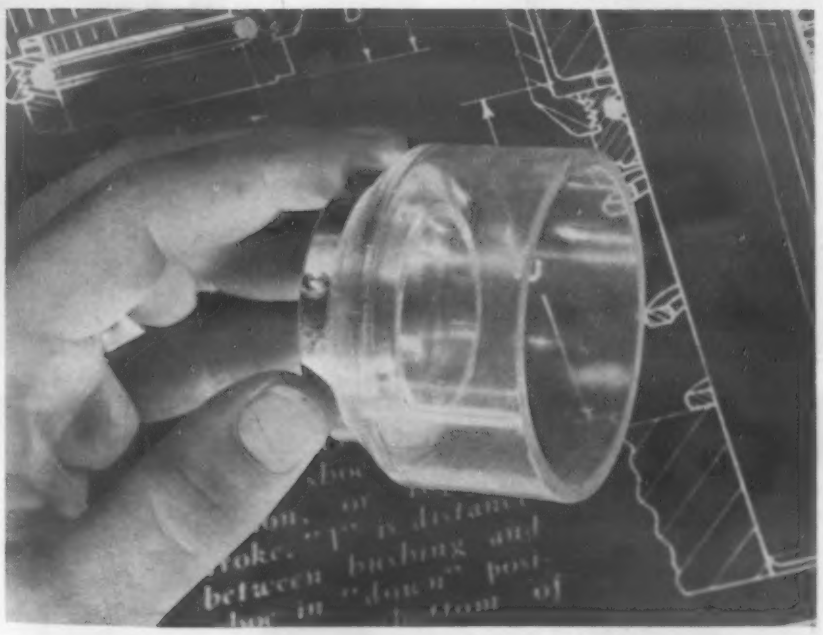
ALL-BRASS COMBINATION WINDOW

This combination screen and storm window is manufactured from 70-30 cartridge half-hard brass and the screen frame is extruded architectural bronze. Produced by B-M-S Inc., the unit fits flush with the outside and incorporates double-thick glass in brass frames and channels. A narrow brass insert at the bottom of the window can be removed if only a small amount of ventilation is required. A slip joint with 5/8-in. play takes up expansion or contraction of house walls and permits ready adjustment to non-standard installations. The removable screen is made of Lumite.

CORED STEEL AGITATOR BLADES

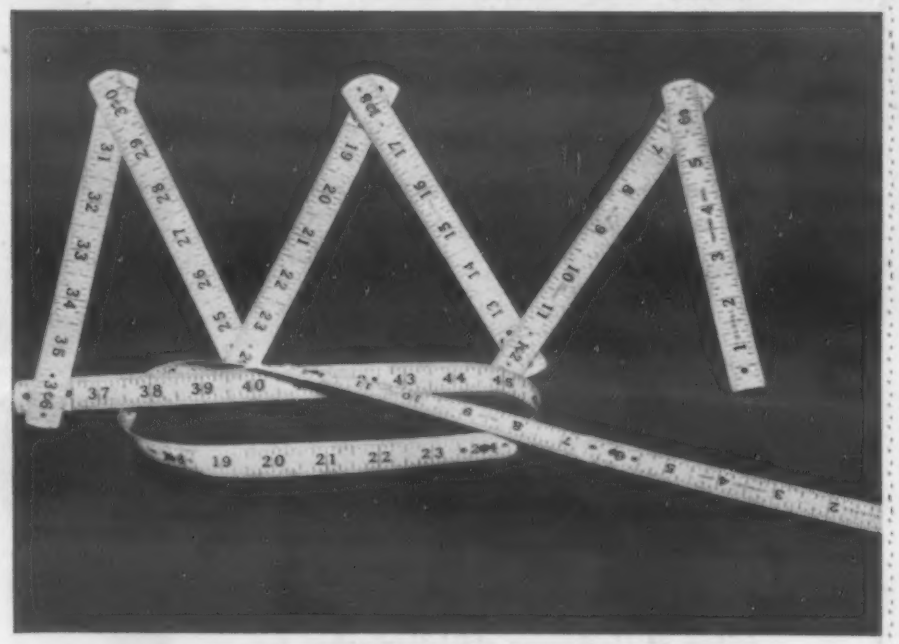
Measuring 7 ft. 6 in. in length and weighing 1550 lb. each, these stainless steel sigma blades are used as agitators in a basic process of plastic manufacture. Cast by the Cooper Alloy Foundry Co., Hillside, N. J., each blade has a 1½-in. hollow core running its full length to provide constant cooling or heating by means of water or steam.





TRANSPARENT PLASTIC OIL CUP

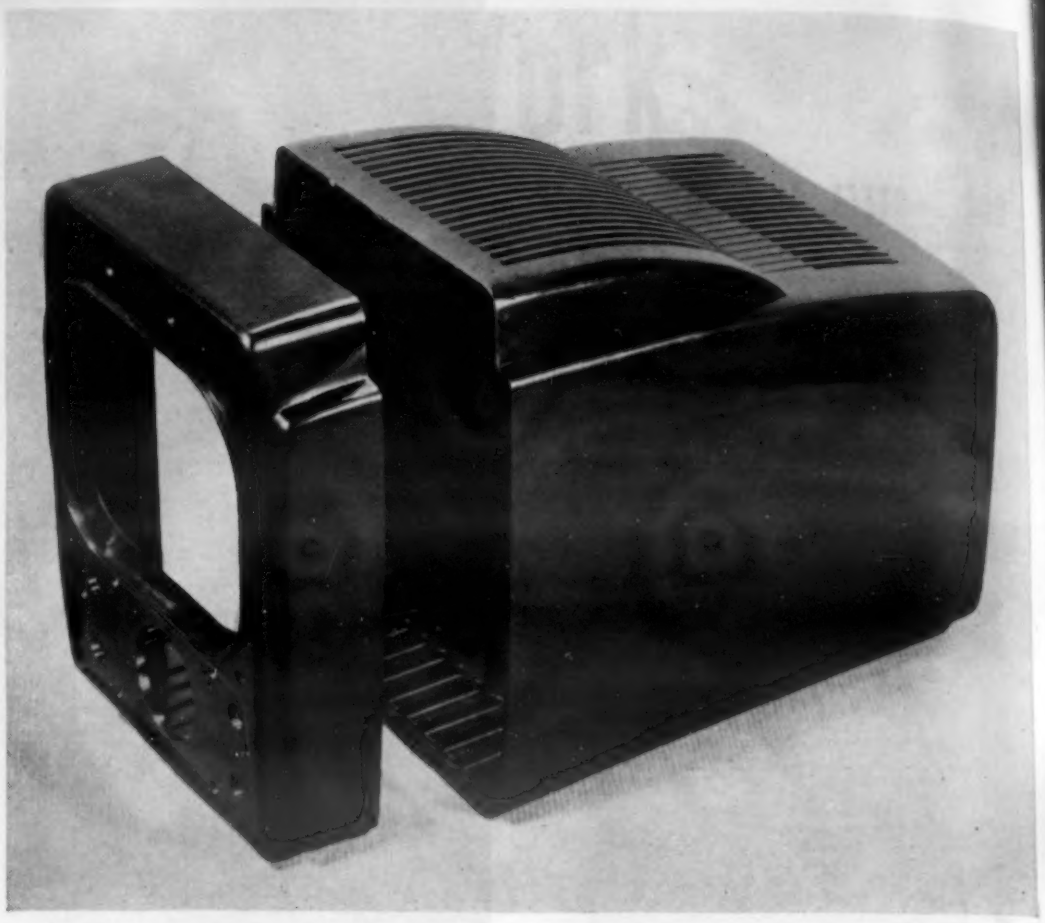
Claimed to assure positive, dependable lubrication of pins and bushings on vertical die sets, this transparent Tenite oil cup is molded by the Die Supply Co. over a brass insert, which is fitted with a neoprene ring to prevent loss of lubricant and to wipe abrasive dirt from the pins. The transparency of the cellulose acetate butyrate from which the oiler is made simplifies inspection of lubrication flow.



FLEXIBLE STEEL FOLDING RULE

Made of a special hardened and tempered alloy steel by the Durall Tool Corp., this 6-ft. folding rule can be bent and twisted to virtually any angle yet will always spring back to its normal shape. The joints pivot on a bearing surface of hardened alloy steel, the rivet fully enclosed and protected from wear and rubbing. A bright white enamel is bonded to the pretreated steel and baked to achieve a hard and adherent finish. The concave cross-section is designed to protect the numbers and graduations from wear.

Materials at Work

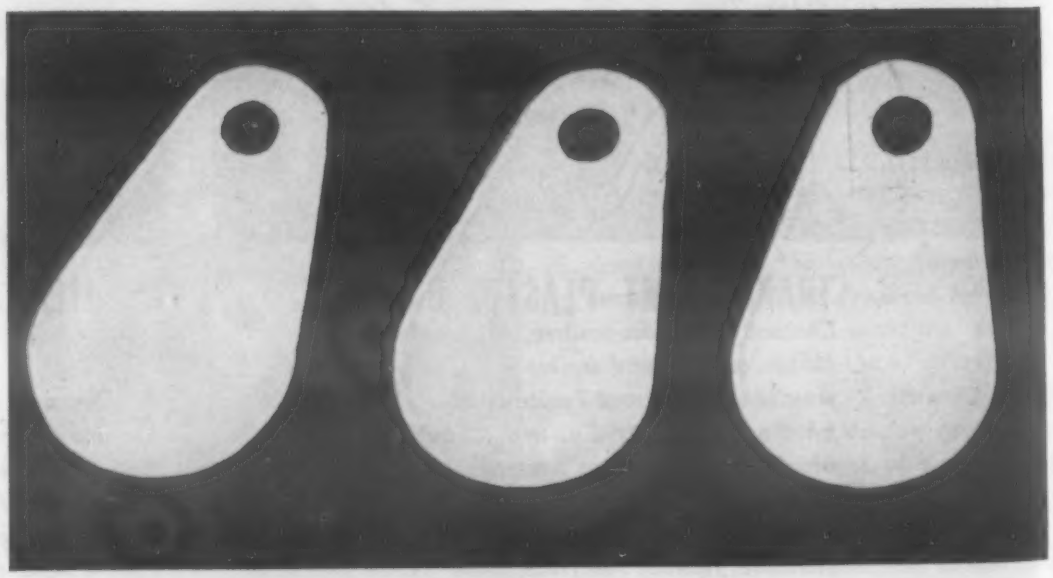


PLASTIC TELEVISION CABINET

Comprising two parts and weighing 11 lb., this phenol-formaldehyde television cabinet is reported to be the largest unit of its type ever fabricated by compression molding. The largest section is 15 in. high, 11½ in. wide, and 17 in. deep and has an average wall thickness of 3/16 in. Produced by G.E. Plastic Div., the face of the cabinet has a large picture opening framed with a projecting head. Louvres in the top of the case permit full ventilation. Felt pads attached to the base prevent marring of surfaces upon which the receiver is placed. The TV chassis with 10-in. picture tube is assembled to the plastics face panel and then locked through an opening in the back of the case.

MOLDED-ON PLASTIC HANDLES

Injection-molded directly on steel hacksaw-frames, these cellulose acetate "pistol-grip" handles withstand separation and twisting stresses and add strength and rigidity to the metal frames. Produced by the F. J. Kirk Molding Co., the handle units clean easily, will not rot or crack, and reduce the number of assembly operations that were formerly required.



NYLON SPRAY GUN VALVE

Repeated failure of clockspring steel flap valves led to the use of nylon valves in a paint spray gun. These valves, actuated by air pressure from the compressor piston, were required to withstand continuous flexing. The steel valves, 0.001 in. thick, failed in test after 2 hr. of use. The plastic substitute, 0.015 in. thick, produced by the Polymer Corp., continued to operate satisfactorily after 100 continuous hours of use.

Materials & Methods Manual

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and application

49

Thermosetting Plastics

by Kenneth Rose, Western Editor, Materials & Methods

Thermosetting plastics make up one of the two main classes of that diverse group of industrial materials known as plastics. As a class they are usually stronger, harder and frequently lower in cost than thermoplastics, the other main class. In order to assist the user of these materials, this manual covers the kinds of thermosetting plastics available, giving detailed descriptions of their performance characteristics and properties, and methods of fabricating them.

Contents

Introduction

In that diverse group of industrial materials known as plastics, a reasonably sharp dividing line has been noted (see "A Plastics Primer for Engineers," MATERIALS & METHODS Manual No. 25, Apr. 1947) between those that polymerize or cure to infusible form and those that can be resoftened by heating. The former group, the thermosetting plastics, are or can be stronger, harder, frequently lower in cost, and more resistant to distortion at somewhat elevated temperatures. Color possibilities are usually more restricted. Fabricating methods are influenced by the dividing line.

The materials in this thermosetting class are the subject of this manual. In addition to their introductory study in "A Plastics Primer for Engineers," they have been considered in more detail in one important form ("Plastic Laminates," MATERIALS & METHODS Manual No. 19, Sept. 1946). Laminated thermosets, and the machining of thermosetting plastics, will therefore be discussed in less detail than other forms of these materials. Several types introduced within the past few years will be included here as well.

The thermosetting plastics form a group broad in itself, but its various chemical families show enough resemblance to permit a few generalizations about them. They are:

(1) Strength properties are usually higher. Tensile strength and impact resistance reach the highest values obtained for any of the plastics in laminates of thermosetting resins with glass fibers. Because of their generally better temperature resistance, the thermosets have better creep resistance, especially at slightly elevated temperatures. They are usually harder also.

(2) Molding processes are different. The thermosetting materials use compression and transfer molding, and sometimes a modified injection process, for high-pressure work, and various types of bag molding for low-pressure laminating. The thermoplastic materials are generally molded by injection because it permits them to use a shorter cycle, but they can use the other methods.

(3) Laminating is ordinarily done with the thermosets. While some laminating, such as with cloth to retain flexibility, can be done with certain thermoplastics, especially the vinyls, the more usual types of laminating make use of thermosetting resins. As the laminates include the strongest and most rigid plastics, they are the materials most used for structural purposes.

(4) The thermosets include the lowest-cost synthetic plastics. Certain of the general-purpose phenolics cost about 17¢ per lb., which, considering their light weight, makes them competitive with most of the structural metals on a cost basis.

(5) The thermosets cannot be heat-welded, but can be adhesive-bonded.

An understanding of the thermosetting plastics requires a knowledge of the process by which they are made, and of the terms that describe the types of material in process and in finished condition. It is not the purpose of this manual to supply information to the resin manufacturer, but rather to assist the user of thermosetting plastics by describing the kinds of material available to him, and giving him general information as to the properties of these materials. For this reason the manufacture of the resin is summarized very briefly, and only insofar as it is varied to change the properties of the finished resin.

The resin manufacturer works with chemicals as his raw material, and converts these, by polymerization or by condensation reaction, into a *resin*. If the resin has been prepared as a liquid, incompletely cured, and intended for pouring into molds in which the cure is completed, it is a *casting resin*. *Varnishing resins* are those intended for application, in the form of a solution or varnish, to fabric or other laminating material. Other resins are converted into *molding powder* or *granular molding material* by addition of a filler and perhaps other ingredients. The resin as produced by the resin manufacturer can be made to various degrees of advancement of the cure, resulting in a resin in which the processing to complete the cure to the infusible state may be short or long. This permits latitude in preforming or postforming, or in the rate of molding, etc. The resin manufacturer does not have complete control over all of these variables for all thermosetting resins, but he can supply a material that will best meet the requirements of the resin user if fully informed of those requirements.

The resin will be the principal element in the formulation for a *plastics* material. An accelerator will probably be added to the casting resin, along with pigments or dyes, etc. Filler, organic or inorganic, will be a part of the formulation of a molding material. Solvents or plasticizers may be used to make up a coating preparation. When the resin has been made up into a formulation and the cure completed, either in a mold as a casting at room temperature and no applied pressure, or in a press under heat and pressure, the product is a thermosetting *plastic*, complete and incapable of being again molded or shaped, except for the possibility of limited change through postforming, or by machining. The thermosetting plastics include the phenolics, the amino-formaldehydes, the aniline-formaldehydes, the furfural and furfuryl compounds, alkyds, and certain types called polyesters. A type of polystyrene polymerized to obtain cross-bonding also possesses thermosetting qualities. Each of these type classifications is produced in several compositions, and the composition types are in turn produced in a variety of formulations. The thermoset classification is shown in the chart.

Of all the thermosetting resins, the phenol-formaldehyde compositions are the cheapest and most versatile. They form the general purpose materials of the classification, and the other members are used where their special features justify their somewhat higher price. The phenol-formaldehydes become the basis for resinous adhesives; with an organic solvent, they become laminating varnishes; as molding materials, they possess good strength, good electrical properties, fair color possibilities, good heat resistance; they become important liquid casting resins. Each of the other thermosets, however, possesses certain properties that give it a preference for one or more of these uses, and warrant payment of a premium price to obtain these special features.

Among general purpose materials the phenolics would be first considered because of their good properties in all lines and their low cost. If the article were required to possess good light transmission (translucency), as for lamp shades, etc., in combination with the structural properties of the phenolics, the urea-formaldehydes, somewhat more expensive than the phenolics, would probably be chosen. Molding compounds, laminates, and casting resins in light colors are available in the urea-formaldehyde formulations. If the application were to require excellent resistance to water, or better chemical resistance than the ureas could offer, in addition to the structural properties of the phenolics and the light color possibilities of the ureas, the melamines would probably be the preferred materials. Such articles as molded tableware illustrate the choice.

The polyesters, relatively new as standard thermosets, are available in thermoplastic form in some compositions. They are not general purpose materials in the same degree as the others in the series, but some types are suitable for use as liquid casting resins, and other types are moldable. Because of its ability to polymerize without applied pressure, and its rather high cost, its use has been largely in the field of low-pressure laminating, and with glass fibers as the laminating material.

Resorcinol-formaldehyde compounds go into the making of resinous adhesives for plywood, and as an ingredient in other formulations. Phenol-furfurals have certain advantages in molding cycles, and aniline-formaldehydes show good electrical properties combined with good chemical resistance. The new alkyd compound affords possibilities of a very short molding cycle combined with excellent electrical properties.

Thermosetting Plastics	Phenolics	Phenol-formaldehyde—many variations in composition Resorcinol-formaldehyde—for wood adhesives Phenol-furfural—easily molded
	Aminos	Urea-formaldehyde—wide color range Melamine-formaldehyde—good electrical properties
	Anilines	Aniline-formaldehyde—several condensation products formed
	Furanes	Furfuryl alcohol—for coatings
	Polyesters	Esters of allyl alcohol—low pressure resin
	Alkyds	Alkyd compound—short molding cycle

Phenol-Formaldehyde Plastics

The condensation reaction of phenol and formaldehyde produces the resin that forms the basic component in one of the most versatile of the plastics families. The resin goes into production of adhesives, coatings, molding materials, extruded plastics, laminating varnishes, impregnants, and casting resins.

General properties of the phenol-formaldehyde resins and plastics are:

(1) Good acid resistance. Strong oxidizing acids such as nitric acid will attack the material, but it is unaffected by the weaker acids.

(2) Fair alkali resistance. Strong solutions of caustic soda dissolve phenol-formaldehydes.

(3) Good electrical properties. Dielectric strength of the material is high, but arc resistance is rather low. Proper choice of fillers is an important consideration in obtaining maximum electrical properties in the finished plastic.

(4) Good bonding strength. Resin-bonded plywood and resin-bonded abrasive wheels make use of phenolic adhesives.

(5) Color possibilities are generally confined to the darker colors. (A casting resin, highly plasticized, and made by a process in which the cure is arrested to permit water to escape, is clear).

(6) Compatibility with other ingredients is wide.

(7) The resin is soluble in ketone solvents.

Phenol-formaldehyde resins—The resin is produced as a powder, lump, liquid, solvent solution, or water dispersion, the last-named usually called a water solution. It is also produced in a thermoplastic form as a modified phenolic oil-soluble resin for certain special applications, such as compounding into paints, printing inks and waxes. Certain features of the resin production process are carefully controlled to provide a variation in properties of the resin. Some of these are:

(1) Variations in the primary constituents to obtain some special property in the finished resin.

(2) Variations in the percentage of phenolic and aldehyde constituents.

(3) Variations in the type and amount of catalyst. An acid or an alkaline catalyst can be used, and in small or large quantity.

(4) Degree of advancement of cure. This is one of the results of several of the above variations.

The properties to be developed in the finished resin are determined by (1) the use to which it is to be put; (2) the equipment in which it is to be finished; and (3) the processing conditions for finishing. Careful outlining of such information to the supplier of the resin will help him to "tailor" the resin to the needs of the user.

Phenol-formaldehyde molding materials—When the proper resins are combined with any of a number of fillers, a phenolic molding material is obtained that can be shaped under heat and pressure in compression or transfer molding presses. The phenol-formaldehyde resin may contain some phenol-furfural also. Fillers can be organic or inorganic, fibrous or powdery. One of the cheapest and most used fillers is wood flour. Diatomaceous earth, a form of silica, mica platelets, and asbestos are mineral fillers much used, while chopped cotton cord, chopped cotton fabric and cotton flock are organic fibrous fillers, and walnut shell flour is a powdered organic filler. A glass fiber filler cut to short length strands is also available. This last filler material is quite new, and has not as yet been used with the phenolics, but is available for such use if needed.

Molding materials in this plastics family are of four general classes, as follows:

I—*General-purpose phenolics.* The most easily molded of the phenol-formaldehydes. The filler is usually cellulosic, and wood flour is the favorite. Mold shrinkage may be rather high. Water absorption is increased, and therefore, electrical properties are not maintained at high values. Heat resistance is likewise low.

II—*Heat-resistant phenolics.* Mineral fillers are used to maintain heat resistant qualities in the resin. Parts are more difficult to mold, the dies are more rapidly abraded by the filler, and the finished parts are more difficult to machine. Mold shrinkage is lower than for the general purpose materials, however.

III—*Shock-resistant phenolics.* Resistance to breakage is increased by use of fibrous fillers to provide reinforcement. Paper or cotton fabric fillers, or cotton flock or cord, serve to increase shock resistance when maximum effect is needed, while asbestos fiber will provide impact resistance to a less degree, but with a measure of heat resistance combined.

The fibrous fillers make the material more difficult to mold, and the increase in molding difficulty parallels the increase in shock resistance. Impact strength of some of the best cord-filled phenolic molding materials may be as much as 20 times that of the general-purpose phenolics.

IV—*Special-purpose phenolics.*

(a) Molded bearing material. An antifriction constituent, such as graphite, can be added to the phenolic.

(b) Materials of high chemical resistance. Mineral filler and careful processing account for the excellent resistance to chemical attack.

Typical Properties of Molded Phenolics

	General Purpose, Cellulose Filled	Shock Resistant, Fabric Filled	Shock Resistant, Cord Filled	High Frequency Insulation, Mineral Filled	Heat Resistant, Mineral Filled
Tensile Breaking Stress, Psi.	6500-8500	5000-8500	3300-9000	3900-7000	4000-6000
Breaking Stress in Compression, Psi.	28,000-36,000	20,000-30,000	15,000-24,000	15,000-25,000	15,000-35,000
Impact Strength, Izod, Notched, Ft.-Lb./In.	0.24-0.46	0.75-2.00	4.05-8.0	0.30-0.38	0.23-0.42
Rockwell Hardness	M110-120	M94-120	M100-120	M100-110	M95-115
Dielectric Strength Short-Time ⅛ In. V./Mil Step-by-Step ⅛ In. V./Mil	 72-425 63-375	 200-365 150-275	 200-325 150-270	 300-460 275-390	 178-350 150-325
Loss Factor 60 Cycles/Sec. 1000 Cycles/Sec. 10^6 Cycles/Sec.	 0.25-2.70 0.18-1.60 0.12-0.40	 0.52-3.0 0.22-1.14 0.14-0.42	 0.7-3.1 0.3-1.0 0.20-0.36	 0.05-0.28 0.03-0.14 0.02-0.06	 1.58-14.0 0.54-4.8 0.20-1.20
Arc Resistance, Sec.	5-6	5-6	8	16	5
Heat Resistance, Max. Continuous Service	300-350 F	250-275 F	250 F	250-300 F	350-450 F
Specific Gravity	1.32-1.55	1.34-1.43	1.36-1.41	1.75-1.92	1.52-1.98
Water Absorption, 24 Hr.	0.3-0.80%	0.4-1.20%	0.80-1.75%	0.01-0.07%	0.10-0.30%

Compression Molding Temperatures	General Purpose, Cellulose Filled	Shock Resistant, Fabric Filled	Shock Resistant, Cord Filled	High Frequency Insulation, Mineral Filled	Shock and Heat Resistant, Mineral Filled	Heat Resistant, Mineral Filled
	290-380 F	290-380 F	280-380 F	300-330 F	290-380 F	290-380 F

Some Properties of Cast Phenolics

	Specific Gravity	Effect of Light	Water Absorption, 24 Hr.	Ten. Str., Psi.	Impact Str., Izod, Notched, Ft.-Lb./In.	Arc Resistance, Sec.
General Purpose and Decorative	1.31-1.32	Yellows slightly	0.32-0.35%	5000-7000	0.30-0.45	120-140
Mechanical and Chemical	1.31-1.32	Yellows slightly	0.35-0.40%	6000-9000	0.25-0.40	200-250

(c) Special low-loss electrical insulating materials. These are usually mica-filled, and produced with careful attention to processing.

The method of preparing the molding material for actual molding varies with the type of molding to be accomplished, the size and shape of the piece to be produced, and the facilities of the press. Some presses are equipped with measuring devices for measuring the charge of powder or granular molding material, and can use these materials without preforming. For most pieces, however, it is better practice to tablet the molding material into pellets that will accurately deliver the exact charge of material needed to fill the mold cavity with the smallest practical excess, or to preform the piece as a hat section, disk, or other suitable form. This latter type of preforming not only permits accurate charging of the mold cavity, but helps in shaping difficult forms.

Charging of powder or granular molding material directly into the mold cavity is usually practicable for single-cavity molds only, and for those molds in which the material will flow easily. Relatively large-volume molds use measured charges of molding powder to advantage.

For most pieces use of preforms is a distinct economy. The charge is accurately measured and formed into a piece that facilitates loading the molds, whether by hand or automatically. Accurate measuring of the charge also saves wasted material from overcharges and from rejected pieces resulting from slack-filled molds.

Simple tabletting on a preform press to produce cylinders, disks or cubes of the molding material is the most common type of preforming. When the mold cavity is large, several preforms can be placed in each cavity to make up the total charge. When flow of the material presents difficulties, the preform can be made in such a shape as to correspond to the rough outlines of the finished molding. Biscuitting, in which several preforms are made together and the unit pieces are broken off by hand and charged into the mold, is another simplified procedure.

Granular molding material gives more compact and usually more uniform pieces in the preforming press. Molding powders frequently entrap air during preforming. Molding materials with fibrous fillers are difficult to handle in the preforming press, due to their tendency to bridge in the hopper or in the feeding shoe. Automatic vibrators, or measurements by weight, have been used with this type of material, and occasionally double preforming, in which a large preform is first made and then cut down to required size, is successful.

Preforms made with insufficient pressure in the preforming press will break easily when handled, as in loading the molds. Use of too great pressure produces a material that cures rather slowly, however, so the preforming operation requires care in determining best forming pressure. Pressures in the range of 15,000 to 20,000 psi. are much used.

Compression molding of phenol-formaldehyde plastics is probably the most used molding method for these materials, though transfer molding has made recent gains. It is also the simplest molding method. For compression molding, the material, as powder, granules or preform, is placed in the heated mold cavity, the mold is closed, and heat and pressure are applied for a predetermined period. The mold is then opened and the piece removed.

As the material is placed directly into the mold, the mold itself can be simpler than those for other molding processes. There are no gates nor sprues. There is a saving of material also, as the trimmed-off gates and sprues represent an almost complete loss of the plastic.

Preforms can be preheated to advantage in many molding processes, eliminating the volatile constituents in the preform and improving flow in the mold. Preheating also decreases the time of the actual molding cycle somewhat. Dielectric heating is a convenient means of warming the preforms, but hot air ovens can be used where the volume of work is sufficient to justify them.

The press in which compression molding is done will be some form of hydraulic press, with or without mechanical compression features. It may be manually operated, semiautomatic or fully automatic. In the first case, the mold must be removed from the press, the piece ejected manually from the mold, and the mold then recharged and replaced on the press. For semiautomatic operation, the molds remain mounted in the press, ejection pins remove the piece as the mold opens, and the mold is manually recharged. The heating elements, whether steam coils or electric resistance coils, are a part of the mold itself. The fully automatic press has the complete molding cycle under automatic control, and the material is automatically loaded into the mold, the mold closes, heat is supplied, and the mold opens and ejects the work at the end of the cycle.

The molding process consists of (1) lubricating the mold, (2) preheating the molding material, (3) charging the mold, (4) closing the mold, (5) curing the piece, and (6) removing the finished piece. The mold is heated to the molding temperature fixed upon as most suitable for the molding formulation being used—usually 300 to 350 F. The mold can then be touched over with a small quantity of a mold release agent, usually beeswax, a nonoxidizing oil, or one of the silicone fluids. A well-polished mold, properly broken in, will require no lubrication, and is flushed out with compressed air. The molding material, preheated to about 280 F, and made up to the proper weight or volume by preforming or otherwise measuring, is charged into the mold cavity, by hand or by means of an automatic loading device. With a multiple-cavity mold care must be taken to load all cavities at the same time, so that the cure will be uniform. A special loading fixture that holds all the charges can be used. It is placed over the mold, and all charges are dropped simultaneously into the cavities. The mold is then closed at low pressure and allowed to "set" for a few seconds, during which time the material softens and fills the mold. Too long a period at low pressure may cause precuring, with resulting porous parts, but insufficient "set" time may produce pieces with flow lines, or with poor physical properties.

The phenol-formaldehyde reaction is a condensation, and some water is liberated as a reaction product. The molding material also contains small amounts of volatile matter. Releasing the mold pressure for an instant just as the material stops flowing will permit vapors to escape, and is called "breathing" the mold. It immediately precedes the curing period, when the molding material is converted into infusible, insoluble form. During cure the pressure is held at 1000 to 5000 psi. for a period of several seconds to perhaps 15 min., depending upon the type of resin used, the thickness of the part, and the temperature of the mold. Too short a cure period will result in low physical properties, a dull or blistered appearance, or warped pieces, while overcuring causes darkened colors or brittle work.

At the completion of the cure period the mold is opened slowly as the ejector pins come to bear upon the part, and the molded piece is removed. The mold is then cleaned and the cycle repeated.

Transfer molding has cut into the field of compression molding because it permits more rapid operation, and especially because it lends itself to molding of complex parts. It resembles compression molding, except that the material is heated to plasticity in a transfer chamber instead of in the mold cavity itself, and is then forced into the mold cavity by a transfer plunger.

When the part to be molded requires the use of delicate inserts, or when it involves thin sections, transfer molding is the process of first choice. Shaping of a preform for such a part in compression molding would be difficult, and the flow of the material during the precuring stage might dislodge the inserts, or be accomplished with difficulty through or around thin sections. In transfer molding the plastics material is introduced into the mold cavity in a fused state, permitting it to flow around inserts and through thin sections with minimum difficulty. This is especially true when the fibrous-filled materials are being molded.

On the debit side, (1) the mold for transfer molding is usually more elaborate than that for compression molding; (2) there is a loss of material in the cull and sprue with each molding; and (3) the size of the molded pieces is rather limited.

There are several features of the transfer molding process that increase its versatility in the job shop:

(1) Transfer molds can be hand operated. One of the simplest types of transfer molding is that in which a loose plate rides above the mold cavity, and the molding material is melted in the space above this loose plate. Transfer of the fused material is made through ports or gates in the plate, the plunger of the press descending to force the material into the mold cavity. The molded piece and loose plate are knocked out together at the end of the cure.

(2) By preheating the molding material for transfer molding, especially with the use of high-frequency heating, the size of the transfer chamber can be considerably reduced. Adequate preheating brings the material to the press at a temperature near the fusing point, so that only a small additional heat input in the transfer chamber is needed before forcing the material into the mold cavity.

(3) Transfer molding is preferred when

the part to be produced (a) has thin or intricate sections, (b) requires difficult cores or delicate inserts, (c) must be held to close tolerances, or (d) includes small or deep holes.

(4) Several cavities may employ a common transfer chamber. Sprues and runners are incorporated in the mold in the usual manner, and increased production compensates for the more elaborate mold. The mold cost is lower than would be the case if separate transfer chambers and plungers were used for each mold cavity.

(5) Pressure transfer molding, in which an auxiliary ram forces the plastic into the cavity while the clamping ram holds the mold in closed position, saves material by eliminating sprues and holding cull to a minimum.

(6) Special presses using a floating platen can use transfer molds of simplified design. Here the transfer chamber is built into the floating platen, and several sizes of chamber and plunger are available for use with many different molds. The mold cavity is built into a separate plate called a cavity plate. For different parts of the same general size, only the cavity plate need be changed.

Injection molding has never become an important method in the processing of thermosetting plastics. The problem of injecting fused resin into a mold cavity from a reservoir of fused material has been extremely difficult to solve with a resin that hardens to infusibility within a few minutes. Methods tried have included feeding preheated pellets ahead of the injecting plunger, and continuous heating of the powder or granular material so that the fused portion is quickly injected into the mold cavities. Most of these procedures are patented.

Injection molding possesses all the advantages of transfer molding, with higher production as added possibility. Operations become completely automatic after the machine settings have been made.

Extruding of thermosetting plastics has been done commercially in Great Britain for about 10 years, but only recently has it been put upon a practical basis in the United States. It is largely confined to extrusion of tubing, where lengths impractical to mold had been made by winding impregnated stock on a mandrel, and finishing by the usual methods for laminations.

Phenolic tubing is extruded from continuously heated stock much as for injection molding of phenolics. Chopped paper filler seems to be a favored material, as good impact strength is required of the tubing. Cure temperature is about the same as for molding materials of the same composition.

Phenol-formaldehyde liquid casting resins —In contrast to the processes in which the resin is formed under heat and pressure, and simultaneously cured to make that form permanent, the liquid casting resins are poured into molds at room temperature, solidify by chemical action, and are finished by a final baking in an oven at moderate temperature. The molds need not be refractory, therefore, but only watertight and resistant to attack by the resins. Strength is usually a minor factor in considering mold materials also.

Resins for casting are liquids or syrups of high formaldehyde ratio and made with a relatively large amount of fixed alkali catalyst. They resemble the two-stage resins already mentioned, but are especially formulated, usually with addition of an accelerator to speed the final polymerization. The accelerator is added just before pouring the mixture into the mold.

Water is released in the condensation reaction that takes place between the formaldehyde and phenolic constituents. This water comes out as tiny droplets, making the solidifying mixture translucent or opaque. This is one indication of the progress of the reaction.

In addition to the liquid or syrupy casting resin, the formulation for a casting material will include a stated amount of accelerator. The amount of accelerator used will largely determine the time required for the mixture to solidify, and the length of baking required to complete the reaction. Thus, a casting resin without accelerator may require a 24-hr. bake at 200 F to harden; with the usual 8% accelerator, 4 hr. standing at room temperature and 8 hr. baking at 140 F is typical; with 12% accelerator, the casting mixture begins to set up quickly at room temperature, and a short baking completes the cure. Use of too much accelerator tends to weaken the casting.

Even without the accelerator the casting resins tend to harden gradually at room temperature. They should be stored in a cool place, with the temperature below about 50 F.

Fillers can be included in the formulation when desired, the usual purpose being to reduce shrinkage of the cast piece. A powder composed of ground asbestos and talc is used with cast phenolic dies with considerable success.

Acid-fast dyes can be used with cast phenolics, but when the amount of accelerator is large the piece is usually colored with a pigment. Most of the resins darken upon standing, so darker colors are preferred.

Molds for phenolic resin castings are made of glass, lead, rubber, treated plaster of Paris, low-melting alloys, wood, treated fiberboard, certain plastics, etc. Lead is one of the most widely used materials, because of the ease with which it is made into molds of various types, and by many methods. Rubber and plaster of Paris molds are also made to complicated shapes over a master form without the necessity of difficult machining. It is this ability to take form in molds easily and cheaply produced that is one of the principal advantages of the casting resins. Some of the important mold types are:

(1) Split molds. A high-production casting device, usually made of lead. Each mold is made in two pieces, and the backs of the mold sections are frequently made to interlock with the backs of adjoining molds, permitting the building up of a large block of molds into a unit. The molds are closed except for the gate. Undercuts can be part of the design as long as they do not interfere with the opening of the mold sections.

(2) Molds made with dipping arbor. These are usually of lead also. A steel dipping arbor is made to the outside dimensions of the piece, and dipped into molten lead so that a coating of lead is formed over the steel. This lead coating is carefully stripped off to form the mold. Undercuts cannot be formed into molds made by this method, but scallops, beads, and similar features can be reproduced if they follow the direction in which the castings will be withdrawn from the mold. Metal cores can be inserted in the lead molds to produce hollow castings.

(3) Rubber molds. Where the form to be cast is too irregular to permit withdrawing from a conventional mold, or where undercuts would cause difficulties, rubber molds can be made by spraying or dipping a model with rubber latex until a substantial coating is formed. The rubber should be ⅛ in. thick or more. This rubbery coating is then split at a convenient place, the model is removed, and a plaster of Paris shell is built around the rubber mold, with provisions for splitting the shell along the same line as for the rubber mold. The shell provides rigidity for the mold. Plastics castings can be made in the rubber mold with its plaster reinforcing, the cast material cured, and the piece then withdrawn by opening the reinforcing and stripping the rubber mold from the casting.

(4) Plaster of Paris molds. This technique is particularly successful in producing such tools as forming dies for light-gage metals, complicated punch dies, and drill jigs. Plaster of Paris is spread over a model, removed, and coated with a parting compound such as high-melting wax. The casting liquids are poured into the mold and cured. Steel punches have been embedded in the resin to produce a quickly-made tool.

Phenol-formaldehyde laminates — Laminated phenolics, made by impregnating sheet materials with solvent varnishes of the resin and curing, have been described in detail in the MATERIALS & METHODS Manual No. 19, "Plastic Laminates." They are listed by broad types only here. These are:

Cellulose paper-base—In several grades, each intended for particular uses. The paper can be kraft, rag or wood alpha, or Mischerlisch pulp.

Cellulose fabric-base—In several grades. A variety of weights and weaves of cotton or linen fabric are used as the basic materials.

Asbestos-base—Asbestos paper or fabric can be used, depending upon the properties required.

Glass fiber-base—Available as woven fabric, as unwoven placed fibers, and as short, loose fibers. This material is more widely used with some of the other resin laminating varnishes.

Laminates of the phenolics are found in both the high-pressure and the low-pressure groups. Because other resins possess better polymerizing qualities at low pressures, the phenolics are more generally used in the high-pressure field.

Properties of General Purpose Urea-Formaldehyde Molding Material*

Specific Gravity	Effect of Light	Water Absorption, 24 Hr.	Heat Resistance, Max. Cont. Serv.	Ten. Str., Psi.	Impact Str., Izod, Notched, Ft.-Lb./In.	Dielectric Strength		Loss Factor			
						Short-Time ⅛ In. V./Mil	Step-by-Step ⅛ In. V./Mil	60 Cyc. per Sec.	1000 C.P.S.	10^6 C.P.S.	Arc Resistance, Sec.
1.47-1.52	Negligible	0.4-0.8%	170 F	6000-13,000	0.25-0.35	300-400	250-300	0.3	0.2	0.2	100-150

* *Alpha-cellulose filled*

Urea-Formaldehyde Plastics

The urea-formaldehyde plastics are formulated from resins obtained by the condensation of urea and formaldehyde. The products resulting from incomplete reaction, similar to the first-stage resins in the phenolic group, are water-soluble, fusible, and can be produced in an alcohol-soluble form. Catalysts used with the urea-formaldehydes are usually acidic in nature.

Some idea has already been given of the place of the ureas in the thermosetting plastics picture. Because of their higher price, they are chosen over the phenolics only when their special features give them an advantage. These features are:

(1) Wide color range, including whites.

(2) Absence of odor or taste. This feature gives the ureas preference in such applications as closures for containers of foodstuffs and medicinals, molded parts for refrigerators, items of kitchenware, and as an impregnant in food wrappers.

(3) Good water solubility. The ureas are superior to the phenolics in the solubility of the partially cured resin. For this reason they go into sizing of high wet-strength papers of many kinds.

(4) Better arc resistance. The ureas show superior nontracking qualities, and are frequently chosen for electrical switchgear because of it.

Urea-formaldehyde resins—As with the phenolics, the properties of the resin can be varied by modifying the composition and the degree of cure of the prepared material. The resin is used in water or solvent solution for adhesives of several kinds, both hot-setting and room temperature-setting; for impregnating wood; for beater or tub sizing of paper to develop high wet strength; as a coating for paper and textiles; as a finishing treatment for textiles, to reduce shrinkage, water absorption, and creasing; as a sand core binder for foundry use; as laminating varnishes in solvent solution; for production of forms soluble in organic solvents for baking enamels; with a foaming agent, for production of foamed insulation; as a leather dressing; and in production of molding powder and granular molding material.

Urea-formaldehyde adhesives and bonding agents—The urea-formaldehyde adhesives for plywood have the advantage over phenolics of avoiding discoloration of the wood, and of being cold-setting in some forms. For this reason they are preferred for fine furniture veneers, especially with the light-colored woods.

Adhesives of this composition are primarily water-soluble bonding agents, in contrast with the phenolics, which are usually solvent types. They are formulated with an acid catalyst, and cure rapidly. They can be prepared in either hot-setting or cold-setting forms, whereas the phenolics are used for hot-setting adhesives only. Water resistance is somewhat inferior to that of the phenolics, so the urea-bonded plywoods are not intended for exterior use.

A feature of the urea-formaldehyde adhesives is that they will tolerate addition of considerable amounts of wheat flour as an extender. The cost of the adhesive is lowered in this way, and the adhesive produced will have ample strength and water resistance for many purposes. Rye flour and walnut shell flour are other extenders sometimes used.

Urea-formaldehyde adhesives are used for paper-backed abrasives also. The phenolics are standard adhesives for the bonding of abrasive wheels, especially if the wheel must run in water or water emulsion as a coolant.

As a core binder, the urea resins are especially chosen for aluminum and magnesium foundries, while the phenolic core binders are used with the ferrous metals. The decomposition temperature of the ureas seems to adapt them to this service with the light metals, and the higher decomposition temperature of the phenolics makes them more suitable for use with the higher liquid temperatures of the molten ferrous metals.

Use of ureas as sizing for papers required to have high wet strength is of recent date. They are inferior to the melamines for this purpose, but are somewhat cheaper.

Urea-formaldehyde molding materials—The resins are formulated with cellulose fillers only, in line with the early discovery that the ureas gave best results with slightly hygroscopic fillers. Alpha cellulose is the filler most used, but other specially purified pulps, and paper and wood flour are also used. The resin is available as a powder or granular material.

Strength of the molded ureas is comparable to that of the general purpose phenolics. Its molding characteristics are so similar that the same molds can frequently be used for both. Molding temperatures for the ureas are somewhat lower than for the phenolics—ordinarily in the range of 270 to 330 F. Pressures will be about 2000 to 8000 psi. The cure time will be from 30 sec. to 10 min. for most pieces.

As the plastic is translucent white, and does not discolor upon standing, any color can be obtained by addition of dyes to the molding material. This ability to take light shades, and to permit accurate matching of colors, is one of the outstanding advantages of the ureas. With the proper selection of dyes the material is light-fast also.

The molded plastic shows good resistance to organic solvents, and to dilute acids and alkalies.

As the light colors and translucency are reasons for selecting the ureas for a given application, the material must be carefully guarded against contamination. A speck of black or opaque material will be clearly visible in the part when light shines through the molded piece. A press using urea molding material is usually screened by plywood or canvas sheets to reduce danger of inclusions of foreign matter. Both compression and transfer molding are used.

Urea-formaldehyde specialties—Foamed urea resin was developed for use in aircraft during the war. Addition of a foaming agent to the resin, and subsequent liberation of gas upon heating, produces a cellular form of the urea of very low density. The formed piece is usually coated with rubber latex to improve strength and to seal the surface.

Baking enamels have utilized the thermosetting resins to provide a durable surface on metal or wood. They show good color and excellent color stability. These enamels are made up with about 50% resin and modifiers, and with coal tar and petroleum derivatives as vehicle. The coatings are baked at about 225 to 300 F, with special formulations available to dry at 125 to 150 F. Other resins are compounded with derivatives of the alkyds. These baking enamels have been shown to be exceptionally durable in such applications as refrigerators, bathroom equipment, and lighting fixture reflectors.

Other coatings made with urea-formaldehyde resins, modified with alkyds, include a low-cost floor covering using a paper base; a fire- and weather-resistant coating for fabrics, and a coating for paper and fiberboard in the packaging field.

Urea-formaldehyde laminates—Laminates using the urea-formaldehyde resins are made with the cellulosics only. Impregnated paper and fabric are laminated in the usual way, with the product usually confined to light-colored items. Table tops and translucent lamp reflectors are typical of the uses to which the material is put.

Melamine - Formaldehyde Plastics

With the melamine plastics the indicated progression of properties continues. Melamine-formaldehyde plastics are slightly more expensive than the ureas; they have all the advantages of the ureas, with the added features of better water resistance, and somewhat higher resistance to attack by dilute acids and alkalies. They can be used with all fillers, including glass fibers. Like the ureas, they possess good arc resistance. The versatility of the melamines in being compatible with mineral fillers makes it possible to utilize this resistance to arcing more fully than in the case of the melamines.

The melamines are odorless and tasteless, like the ureas, and so are suitable for use in contact with foodstuffs.

Melamine-formaldehyde resins—The melamine resins can be cured in the presence of either acid or alkaline catalysts, and so can be finished under a wider range of conditions than the ureas. The resin is only slightly soluble in water, so cannot be used in water solution as are the ureas. Melamine resins are used in compounding laminating varnishes, molding materials, dressings for cloth, sizings for wet strength papers, and solutions for adhesives.

Melamine-formaldehyde molding compounds—When melamine resin is formulated into a molding compound with alpha cellulose fiber as the reinforcing material, a product capable of being finished to a hard, tough plastic is the result. Molded melamines are harder and more abrasion-resistant than the ureas. For general-purpose molding a wood-filled material is available, and even this composition possesses excellent arc resistance. A high-impact material made with cotton rag filler shows good flexural strength along with impact resistance. Heat-resistant grades are made with asbestos as the filler, and these combine high arc resistance with their elevated-temperature characteristics, making them valuable material in the electrical field.

Because of its better resistance to water, even at boiling temperatures, molded melamines have gone into the button field extensively. The same properties, together with its ability to take and hold a good surface finish, have given it a preference in such lines as hospital food trays and domestic tableware.

Melamines are especially suited to transfer molding. Even the fiber-filled materials show good moldability. Dimensional stability is somewhat better than for the ureas, and molding conditions are much the same.

Melamine-formaldehyde laminates—Interesting combinations in the laminating field include a glass fiber laminate made

with melamine resin for electrical panels. It has high strength, good heat resistance, and excellent electrical properties. A low-pressure laminate uses a combination melamine-glass fiber laminate, and cotton fabric laminates are used decoratively where their good color properties and durability are desirable.

Melamine-formaldehyde specialties—One of the most important uses of melamine resins is in the coating field. High quality baking enamels are based upon the melamine resins, and show (1) a wide range of compatibility with other ingredients, (2) good resistance to discoloration by heat and light, (3) good baking and curing properties, with fast cure to a hard surface at moderate temperatures. Some of the most successful formulations have been melamine-alkyd enamels, in which the melamine resin contributed hardness, durability, and color fastness, and the alkyd acted as a plasticizer and increased adhesion and resistance to chalking.

The melamine enamels for metal finishing might be formulated to bake at about 180 to 250 F, and to cure quickly to a hard thermoset at 250 to 325 F. They are made up with organic solvents as the vehicle.

Melamine resins are finding an important field in the development of high wet strength in papers. Map papers, packaging materials, vegetable bags, and similar articles are given greatly increased resistance to tearing when wet by addition of 1 to 2% of melamine resin. The resin is added in the form of a water dispersion to the stock in the beater, and is cured by the heat of drying in the process of formation of the paper sheet.

Shrinkproofing and creaseproofing of woolens is another field for the melamines. In the treatment of both paper and woolens the melamines have proved themselves more effective than the ureas.

Typical Properties of Molded Melamines

	Specific Gravity	Water Absorption, 24 Hr.	Heat Resistance Max. Cont. Serv.	Ten. Str., Psi.	Impact Str., Izod, Notched, Ft.-Lb./In.	Dielectric Strength		Loss Factor			
						Short-Time, ⅛ In. V./Mil	Step-by-Step, ⅛-In. V./Mil	60 C.P.S.	1000 C.P.S.	10^6 C.P.S.	Arc Resistance, Sec.
General Purpose, Alpha-Cellulose Filled	1.47-1.52	0.1-0.6%	210 F	7500-13,000	0.24-0.35	300-400	250-300	0.22-0.78	0.12-0.31	0.21-0.31	110-180
Electrical Grade, Cellulose Filled	1.45	0.34-0.80%	250 F	5000-9000	0.27-0.36	350-400	250-350	0.12-0.22	0.07-0.27	0.18-0.28	95-135
Intermediate Shock Resistance, Fabric Filled	1.5	0.8-1.3%	250 F	8000-9000	1.1-1.4	130-370	—	3.3-5.0	0.82-1.56	0.30-0.42	8

Polyesters

The polyester resins form an interesting and diverse group, in which compositions and properties vary widely, and only a similarity of use seems to unite the group. Compositions have not been revealed for many of the materials sold under a trade name.

Polyesters are comparative newcomers in the plastics field. They are copolymers of a polyester and, usually, styrene. Final cure is effected with the help of a catalyst, and the result is a thermoset material in which properties are considerably influenced by the compositions of resin and of reinforcement, if any.

The allyls really constitute a sub group, as the allyl esters are not usually copolymerized with styrene. They are polymerized esters, however, and conform to the general group properties.

Some of the general properties of the group are:

(1) Good resistance to chemical attack.
(2) Good strength and toughness.
(3) Ability to cure at low pressures, or at low temperatures.
(4) Low water absorption.
(5) Good optical properties in some formulations.

Polyester resins—The polyester resins, including the allyls, are syrupy liquids of a range of viscosities, light in color, and curing by addition polymerization. The higher-viscosity materials are semisolid. A result of this type of polymerization is that no water is split off during the process, as in condensation reactions of other thermosets, and curing can be done without the need to "breathe" molds or otherwise to provide for escape of water. Control of the composition and cure makes it possible to vary the hardness of the finished material from rigid to almost rubbery consistency, without use of a plasticizer.

A catalyst, usually a peroxide, is added to the formulation to speed the polymerizing process. Storage of the unpolymerized material at temperatures below ordinary room temperature is sometimes advocated, though the allyls are quite stable before addition of the catalyst.

The resins are used as liquid casting resins, for molding compounds, and for laminating.

Polyester laminates—The polyester resins are particularly important in low pressure laminating. Ease of application is one of their outstanding characteristics. Instead of impregnating the fabric with a resin varnish and then curing in a mold, as is the case with the other thermosets, it is possible to lay up the laminating fabric or fibers and to apply the unpolymerized resin, sometimes with a ladle. Such processing is especially helpful in making large pieces with glass fibers as the laminating material. Cure can be completed at temperatures of about 158 F or higher for most formulations, while others will cure at room temperature. Pressures may be 30 psi. or less, and some types will cure at contact pressure.

When building up a laminated part by this simple method, a resin with good initial tack is chosen so that the reinforcement is partially held as the resin is applied. The more viscous resins may be applied by hand, or with a doctor blade if the laminate is in roll or sheet form.

Laminating of large or irregular parts is greatly simplified by use of simple forms of sheet metal, plaster of Paris, glass, ceramics and rubber, as well as the more substantial molds of lead, steel, copper and brass. Use of a rubber blanket inside the form, with pressure applied against the blanket; a rubber bag outside the form, with atmospheric pressure applied by exhausting the bag; and hat press molding, with an inflated rubber bag between paired dies, are the common means of completing the cure with low-pressure laminates. As an illustration of the great possibilities of the method, work is now in progress for the making of a 34-ft. boat hull, to be molded in one piece, with glass fibers as the laminating material and a polyester as the resin.

Low-pressure laminating permits the making of pieces much larger than could be processed between heavy mating dies. The laminating material can be laid up by hand in or over a simple form, the liquid resin applied by hand or by simple applicator, and the piece finished by moderate heating with steam coils in some such vacuum or air pressure device as has been described. The cure will require about 20 min. If desired, the resin may be applied to layers of the laminating material and the material held in storage in sheets or rolls for several days, even with the catalyst present, if a semisolid resin be used. The material can then be laid up in plies in the form and the cure completed by applying light pressure and heat to about 250 F.

Low-pressure laminates show strength qualities that may equal and sometimes surpass those of the high-pressure types.

Typical Properties of Polyester Resins (Without Reinforcing)

	Specific Gravity	Water Absorption, 24 Hr.	Heat Resistance, Max. Cont. Serv.	Ten. Str., Psi.	Impact Str., Izod, Notched, Ft.-Lb./In.	Dielectric Strength		Arc Resistance, Sec.
						Short-Time ⅛ In. V./Mil	Step-by-Step ⅛ In. V./Mil	
Polyester Resin	1.10-1.46	0.15-0.60	250 F	3500-9000	0.3-0.4	380-500	280-420	124
Allyl Resin (Cast)	1.30-1.40	0.034-0.44	212 F	5000-6000	0.2-0.4	380	320	121-126

Polyester casting resins—As would be expected from resins capable of polymerizing at room temperature and no pressure, the polyesters can be readily adapted to casting. Some of the allyls can be produced in a nearly water-clear material that has excellent optical properties, good resistance to scratching, resistance to distortion by heat, and resistance to chemical attack. The material is cast into sheets or other forms, and these are capable of a degree of postforming under heat and pressure even in the fully cured condition.

In addition to the families of the widely applied thermosets that have been given here in the order of their ascending price, there are other materials that, because of cost or because they are very largely taken up by one field, do not fit into this simplified arrangement. Some of these are important materials in their field, and may be regarded as specialties. Others are important as co-materials with the more widely used types.

Special Purpose Plastics

Resorcinol-Formaldehyde Plastics

While resorcinol - formaldehyde resins would have interesting properties as molding materials, their most important use has been in the field of adhesives. As wood adhesives, they show a high bond strength with the material, low-temperature curing properties, and a neutral reaction, with good resistance to weathering. The resin is also used as an adhesive for the phenolics and other plastics, for hard rubber, unglazed ceramics, and asbestos. They can be used in water solution.

The laminating, compounding and scarfing of lumber, much used during the war and after to stretch the available supply of wood, gave a tremendous lift to the use of resorcinol - formaldehyde wood adhesives. Heavy timbers, difficult to obtain in the sizes desired, were built up by laminating a number of boards. Long planks were made by scarfing or otherwise piecing several short sections. For such work the resorcinol adhesives gave excellent results.

Resorcinol-formaldehyde resins are good molding materials, with several valuable properties that frequently bring them into use as an ingredient in a formulation of phenolic resin. One is the ability of the resorcinol resin to take up moisture. For this reason they are sometimes included to absorb free water that might be bothersome. Another is their use with such thermoplastic materials as vinyl polymers to impart water and heat resistance. Another is their ability to cure at a lower temperature than the phenolics, thus permitting proper curing of pieces with thick sections.

Phenol-Furfural Plastics

Thermosetting resins of the phenol-furfural group show an unusual combination of properties as molding materials. At temperatures of about 275 to 325 F in the mold they are readily fused and will flow into the most complicated molds without difficulty. The cure time is unusually long, avoiding any danger of precuring during flow. As the temperature increases to about 375 F, however, the cure time shortens remarkably, and the mold cycle may be shortened. This is used to advantage by preheating the resin to the easy flowing, slow curing range, and increasing the molding temperature to the fast curing stage.

The phenol-furfurals do not burn and stick at the higher mold temperatures, and dimensional accuracy is high. In addition, the plastic shows good resistance to water and to chemicals, good heat resistance, and good electrical properties. As the resin is naturally dark, only dark colors are possible.

The molding qualities described should make this resin the natural one for use in injection molding of thermosets. It has been used in this way with fiber fillers, and the long cycle permits flow of the molding material without danger of clogging.

Furfuryl Alcohol

Furfuryl alcohol can be polymerized in the presence of acid catalysts and other types to a dark colored, infusible solid. Before cure is complete, the resin goes through an intermediate stage as a liquid, and in this condition it possesses interesting properties as an adhesive for phenolics, other types of plastics, ceramic materials, modified wood materials, and natural and synthetic rubbers. The resin is also used as an impregnant and coating where dark finishes are not objectionable.

As an adhesive, the resin shows high bond strength with the phenolics, good water resistance, bonding at low temperatures or at room temperature, and bonding without the use of solvents. Resistance to chemical attack is also high.

Coatings of furfuryl alcohol have been used to seal the surfaces of low pressure laminates; to impregnate forms made of plaster of Paris for use as tools or models; to impregnate building board, wood, etc., with a view to increasing strength and water resistance, and to provide a dark waterproof and chemical-resistant finish for wood.

Aniline-Formaldehyde Plastics

Another resin for laminating or molding is the dark-colored material obtained by condensation of aniline and formaldehyde. It has especially good electrical properties, such as low loss factor, low power factor, and high dielectric strength. The material can be produced in a thermoplastic type, with softening and moldability at about 325 F and about 1500 psi. pressure. Increasing the proportion of formaldehyde results in production of a thermoset.

Chemical resistance is good; alkalies do not attack the resin, though strong acids will affect it. Resistance to organic solvents is good. Its electrical properties give it a place in the radio and television field as an insulator, especially for coil forms, antenna housing, tube bases and terminal boards.

Laminates made with the resin are used in the same field, but electrical properties are not as good with the laminates, due to the lowered resistance to absorption of water.

Alkyd Plastics

The alkyd resins are still confined to two fields for most of their market—the production of coatings, and a molding compound announced at the 1948 Plastics Exposition. There is a strong likelihood that these resins will expand into the general purpose class in the near future, with several new molding compounds to be announced.

Alkyd resins have been important in the coatings field for the past decade and longer. Alkyd resins were used to modify the nitrocellulose lacquers then in use in the automotive industry, giving improved appearance and better weather resistance. They have gone into many different types of finishes, as the principal ingredient in synthetic enamels and as a modifier in paints, lacquers, and enamels with urea-formaldehyde, phenolics, and melamine-formaldehyde resins. They are also used in many types of printing inks, anti-corrosion primers, coatings for textiles, linoleum coatings, baking enamels, etc.

Many different types of alkyds have been developed for use in finishes and coatings. Many are modified with oils, rosin, or rosin derivatives. Oil-modified alkyds, depending upon the type of oil from which they are made, are classified as drying, semidrying, and nondrying alkyds.

The particular features that the alkyds have brought to various finishes in which they are used include:

(1) Increased gloss-retention. Alkyds have reduced the tendency toward chalking in finishes exposed to sunlight and weather.

(2) Improved water resistance.

(3) Resistance to discoloration. Baking enamels modified with alkyds are now used for refrigerators and stoves, hospital furniture, washing machines, etc.

(4) Fast drying properties. Enamels containing alkyds are of both airdrying and baking types. Use of the resins has helped to ease the shortage of drying oils.

(5) Improved adhesion.

With the announcement of an alkyd molding compound, this resin group entered a new field. The molding compound is available as a mineral-filled material only, and so has somewhat lower strength properties than the reinforced thermosets. Shrinkage and water absorption are comparable to those of the phenolics, and electrical properties are somewhat better. Resistance to arc tracking is excellent—190 to 200 sec. Chemical resistance is good also. Organic solvents, oils, weak and strong acids, and weak alkalies have no effect upon the plastic.

The alkyd molding compound has a storage life of about six months if kept in a cool place, at 70 F or lower. Humidity up to about 75% has little effect.

The outstanding feature of the new alkyd is its quick curing ability. Temperature of cure is 275 to 350 F, with 300 F recommended for typical operation. Mold pressures should be just sufficient to fill out the piece, and 400 to 2000 psi. have been used successfully. Under correct conditions cure is completed in a matter of seconds. Because of the speed of cure it is important that the press be rapid-acting and that the mold be closed quickly.

Water resistance, shrinkage, and heat distortion are equivalent to values for the phenolics. Molded pieces retain their strength well upon exposure to 350 to 400 F, even for prolonged periods.

Corrosive Medium	Material										
	ACI	CA 15	CB 30	CC 50	CF 8	CF 8M	CH 10	CH 10M	CN7 MCu	–	–
	CA	14	16	19	17S	17S MO	22S	22S MO	FA 20	MM	Ni
ACIDS											
Acetic 5%, 70 F †	G	E	E	E	E	E	E	E	G	F	
Acetic 5%, boiling	P	G	G	E	E	E	E	E	E	G	
Acetic 80%, 70 F †	P	F	G	E	E	E	E	E	G	P	
Acetic 80%, boiling	P	P	P	F	E	F	E	E	E	G	
Acetic Glacial, 70 F †	E	E	E	E	E	E	E	E	E	P	
Acetic Glacial, boiling	F	G	G	F	E	F	E	E	E	G	
Benzoic 5%, 70 F	E	E	E	E	E	E	E	E	E	E	
Boric 5%, 176 F	G	G	G	E	E	E	E	E	E	E	
Chromic 10%, 70 F	N	G	G	G	G	G	G	G	G	G	
Chromic 10%, boiling	N	F	F	F	G	F	G	G	N	N	
Chromic 50%, boiling	N	P	P	P	G	P	G	G	N	N	
Citric 5%, 70 F	F	F	F	G	G	G	G	G	E	E	
Citric 25%, boiling	N	N	N	N	F	N	F	G	G	G	
Citric 50%, boiling	N	N	N	N	F	N	F	G	G	G	
Formic 5%, 70 F	P	F	F	G	G	G	G	G	G	G	
Hydrochloric 1%, 70 F †	N	N	N	P	E	F	E	E	F	G	
Hydrochloric 1%, boiling	N	N	N	N	N	N	G	G	P	F	
Hydrochloric 5%, 70 F †	N	N	N	N	N	N	P	G	F	F	
Hydrochloric 5%, boiling	N	N	N	N	N	N	N	N	P	P	
Hydrochloric 25%, 70 F	N	N	N	N	N	N	N	P	P	P	
Hydrochloric 25%, 176 F	N	N	N	N	N	N	N	N	P	P	
Hydrofluoric 48%, 70 F	P	P	P	P	P	P	P	E	E	G	
Hydrofluoric 48%, 176 F	P	P	P	P	P	P	P	P	G	G	
Lactic 5%, 70 F	P	F	F	F	G	F	G	G	G	G	
Malic, all temps.	F	F	F	G	G	G	G	E	G	G	
Nitric all concs., 70 F	G	E	E	E	E	E	E	E	N	N	
Nitric 65%, boiling	P	F	G	G	F	E	F	G	N	N	
Oleic all concs., all temps.	F	G	G	E	E	E	E	E	E	G	
Oxalic 5%, boiling	F	G	G	G	G	G	G	E	G	G	
Phosphoric 10%, 70 F †	N	N	N	N	P	N	P	G	G	G	
Phosphoric 85%, 70 F †	E	E	E	E	E	E	E	E	E	G	
Phosphoric 85%, boiling	N	N	N	N	N	N	N	G	F	N	
Stearic concentrated to 200 F	G	E	E	E	E	E	E	E	E	G	
Sulfuric 2%, 70 F †	N	N	P	G	E	G	E	E	G	G	
Sulfuric 2%, 176 F †	N	N	N	N	E	N	E	E	F	F	
Sulfuric 2%, boiling	N	N	N	N	F	N	E	E	F	F	
Sulfuric 5%, 70 F †	N	N	N	F	E	G	E	E	G	F	
Sulfuric 5%, 176 F †	N	N	N	P	G	P	E	E	F	F	
Sulfuric 5%, boiling	N	N	N	N	F	N	E	E	F	F	
Sulfuric 10%, 70 F †	N	N	N	P	E	G	E	E	G	F	
Sulfuric 10%, 176 F †	N	N	N	N	G	N	E	E	F	P	
Sulfuric 10%, boiling	N	N	N	N	N	N	G	E	F	P	
Sulfuric 78% (60° Be), 176 F	N	N	N	N	N	N	N	F	N	N	
Sulfuric 93% (66° Be), 70 F	G	G	G	E	E	E	E	E	F	F	
Sulfuric 93%, 300 F	N	N	N	N	N	N	N	N	N	N	
Oleum, 70 F	P	F	F	E	E	E	E	E	N	N	
Mixed Acids 57% H_2SO_4, 28% HN^4O_3, 176 F	F	F	G	G	G	G	G	E	N	N	
ALKALIES											
Ammonium Hydroxide, all concs.	E	E	E	E	E	E	E	E	F	P	
Calcium Hydroxide 10%, boiling	E	E	E	E	E	E	E	E	E	E	
Calcium Hydroxide 50%, boiling	P	F	F	F	G	F	G	E	E	E	
Sodium Hydroxide or Potassium, all concs., 70 F	E	E	E	E	E	E	E	E	E	E	
Sodium Hydroxide or Potassium < 20%, boiling	G	E	E	E	E	E	E	E	E	E	
Sodium Hydroxide or Potassium 30%, boiling	P	G	G	G	G	G	G	E	E	E	
Potassium, Molten, 600 F	N	N	N	N	N	N	N	F	G	G	
NEUTRAL & ALKALINE SALTS											
Barium Sulfide, 70 F	E	E	E	E	E	E	E	E	E	E	
Calcium Chloride 5%, 70 F	P	P	F	F	G	F	G	E	E	E	
Calcium Sulfate Sat., 70 F	E	E	E	E	E	E	E	E	E	E	
Magnesium Chloride 5%, 70 F	N	F	F	F	G	F	G	E	E	E	
Magnesium Sulfate 5%, 70 F	F	F	F	E	E	E	E	E	E	E	
Sodium Carbonate, all concs., 70 F	E	E	E	E	E	E	E	E	E	E	
Sodium Chloride 5%, 70 F	F	F	F	G	E	G	E	E	E	E	
Sodium Sulfate 5%, 70 F	G	E	E	E	E	E	E	E	E	E	
Sodium Sulfide 5%, 70 F	E	E	E	E	E	E	E	E	E	E	
Sodium Sulfite 5%, 70 F	P	P	F	G	E	G	E	E	E	E	
ACID SALTS											
Alum 10%, boiling	P	F	F	E	E	E	E	E	G	G	
Aluminum Sulfate 10%, 70 F	N	P	P	G	G	G	G	E	E	E	
Ammonium Chloride 5%, 70 F	F	F	F	G	E	G	E	E	G	G	
Ammonium Sulfate 10%, 70 F	P	F	F	G	G	G	G	E	E	E	
Ammonium Sulfate 10%, boiling	N	P	P	F	G	F	G	E	G	G	
Ammonium Nitrate, all concs., 70 F	G	G	G	E	E	E	E	E	E	E	
Stannous Chloride 5%, 70 F	N	N	N	N	F	F	F	E	G	G	
Zinc Chloride, 5%, boiling	N	N	N	N	P	N	P	E	G	G	
OXIDIZING ALKALINE SALTS											
Calcium Hypochlorite 2%, 70 F	N	P	P	F	G	F	G	E	P	P	
Sodium Hypochlorite 5%, 70 F	N	P	P	F	G	F	G	E	P	P	
Sodium Peroxide	N	F	G	E	E	E	E	E	G	G	
OXIDIZING ACID SALTS											
Ammonium Persulfate 5%, 70 F	F	F	F	G	G	G	G	G	N	N	
Cupric Chloride 1%, 70 F	N	N	N	P	F	P	F	G	N	N	
Cupric Sulfate 10%, 70 F	E	E	E	E	E	E	E	E	F	F	
Ferric Chloride 10%, 70 F	N	N	N	N	F	N	F	G	N	N	
Ferric Sulfate, boiling	G	G	G	G	E	G	E	E	N	N	

(CONTINUED ON PAGE 81)

†—Aerated and agitated.

Corrosive Medium	Material										
	ACI	CA 15	CB 30	CC 50	CF 8	CF 8M	CH 10	CH 10M	CN7 MCu	–	–
	CA	14	16	19	17S	17S MO	22S	22S MO	FA 20	MM	Ni
OXIDIZING ACID SALTS											
Mercuric Chloride 2%, 70 F		N	N	N	N	P	N	P	E	N	N
Stannic Chloride 5%, 70 F		N	N	N	P	P	P	P	E	N	G
WET AND DRY GASES											
Chlorine Gas Dry, 70 F		N	N	N	N	P	N	P	G	G	G
Chlorine Gas Wet, 212 F		N	N	N	N	N	N	N	N	N	N
Sulfur Dioxide Dry, 575 F		E	E	E	E	E	E	E	E	G	G
Sulfur Dioxide Wet, 70 F		F	F	F	G	E	G	E	E	F	F
Sulfur Dioxide Solution, 70 F		P	P	P	F	G	F	G	E	F	F
Sulfur Dioxide Spray, 70 F		N	N	N	P	P	P	P	E	F	F
Hydrogen Sulfide Dry		G	E	E	E	E	E	E	E	G	G
Hydrogen Sulfide Wet		F	G	G	G	E	G	E	E	G	G
ORGANIC MATERIALS											
Acetone, 70 F		F	G	G	E	E	E	E	E	E	E
Acid Sludge (50% H_2SO_4), 200 F		N	N	N	N	N	N	N	E	N	N
Alcohol—Methyl & Ethyl		E	E	E	E	E	E	E	E	E	E
Analine Hydrochloride, 70 F		N	N	N	N	P	N	P	G	G	G
Benzol, 176 F		F	G	G	E	E	E	E	E	E	E
Carbon Tetrachloride		E	E	E	E	E	E	E	E	E	E
Chloroform		F	G	G	E	E	E	E	E	E	E
Ethyl Acetate, 70 F		G	G	G	E	E	E	E	E	G	G
Formaldehyde, 70 F		E	E	E	E	E	E	E	E	E	E
Phenol 5%, boiling		G	G	G	E	E	E	E	E	G	G
Refinery Crudes		N	N	P	F	E	F	E	E	G	G
Trichlorethylene, boiling		E	E	E	E	E	E	E	E	E	E
PAPER MILL APPLICATIONS											
Kraft Liquor		E	E	E	E	E	E	E	E	G	G
Black Liquor		E	E	E	E	E	E	E	E	G	G
Green Liquor		E	E	E	E	E	E	E	E	G	G
White Liquor		E	E	E	E	E	E	E	E	G	G
Sulfite Liquor, 176 F		P	P	F	G	E	G	E	E	N	N
Chlorine Bleach		N	P	P	F	G	F	G	G	P	P
Paper Makers Alum		P	F	F	E	E	E	E	E	G	G
PHOTOGRAPHIC INDUSTRY											
Humid Atmospheres		P	G	E	E	E	E	E	E	E	E
Cellulose Acetate		P	P	P	G	E	G	E	E	G	G
Acetic Anhydride		N	F	F	F	E	G	E	E	E	G
Acetic Acid +.1% H_2SO_4		N	N	N	P	F	P	F	E	E	F
Developers		E	E	E	E	E	E	E	E	G	G
Solutions Containing SO_2		P	P	F	F	G	F	G	E	E	G
Silver Nitrate, 70 F		E	E	E	E	E	E	E	E	N	N
FERTILIZER MANUFACTURING											
$H_3PO_4 + H_2SO_4 + HF$		N	N	N	P	F	P	G	G	P	P
PICKLING OPERATIONS											
H_2SO_4 + Dichromate, 176 F		N	N	N	G	E	G	E	E	N	N

Corrosive Medium	Material										
	ACI	CA 15	CB 30	CC 50	CF 8	CF 8M	CH 10	CH 10M	CN7 MCu	–	–
	CA	14	16	19	17S	17S MO	22S	22S MO	FA 20	MM	Ni
PICKLING OPERATIONS											
$H_2SO_4 + HCl$, 176 F		N	N	N	N	N	N	N	F	G	G
CORROSIVE WATERS											
Acid Mine Water		N	F	G	G	E	E	E	E	P	G
Abrasive Acid Mine Water		N	N	G	P	F	P	F	E	N	N
Sea Water		F	G	G	G	G	G	G	E	E	E
Brackish Water		F	G	G	G*	E	G*	E	E	F	F
FOOD AND ASSOCIATED PRODUCTS											
Brines		F	F	F	G	E	G	E	E	E	E
Edible Oils		E	E	E	E	E	E	E	E	E	E
Fats		E	E	E	E	E	E	E	E	E	E
Fatty Acid Distillation		F	G	G	G	E	G	E	E	G	G
Fruit Juices		G	E	E	E	E	E	E	E	G	G
Ketchup		G	E	E	E	E	E	E	E	G	F
Milk Pasteurizing		F	G	G	E	E	E	E	E	G	G
Vinegar & Salt, 70 F		P	F	F	F	G	F	G	E	F	F

RATINGS:

E—*Excellent resistance. 0.004 max. in. per year of penetration. Corrosion so slight as to be harmless.*

G—*Good resistance. 0.004-0.042 in. per year of penetration. Satisfactory service expected; at most a slight etch.*

F—*Fair resistance. 0.042-0.120 in. of penetration per year. Satisfactory service under specific conditions. Light to moderate attack.*

P—*Poor resistance. 0.120-0.420 in. of penetration per year. Satisfactory for temporary service only.*

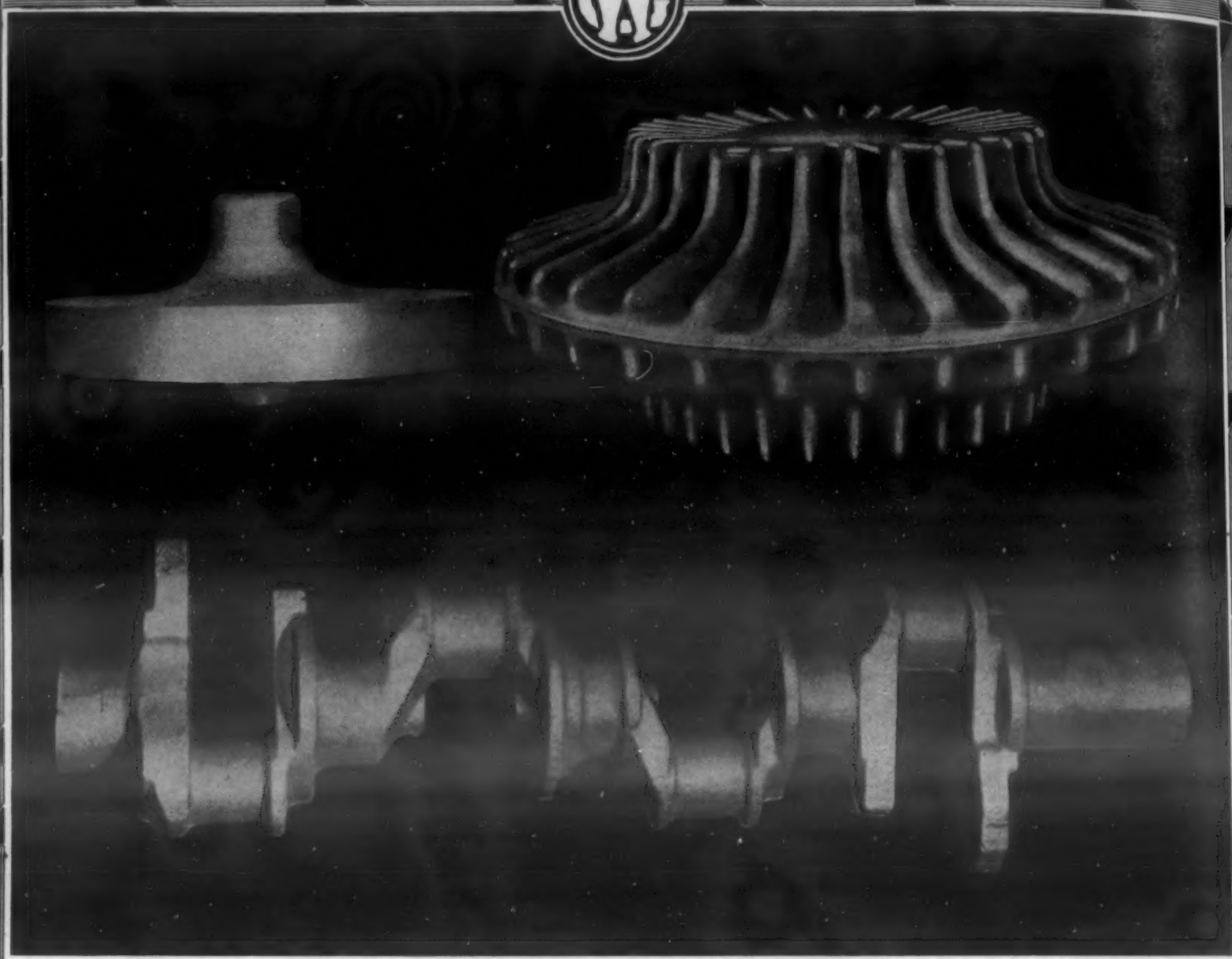
N—*No resistance. 0.420 min. in. of penetration per year. Rate of attack too great for any use.*

*—*Subject to pitting type corrosion.*

Nominal Composition of the Alloys Covered (%)

Material	Cr	Ni	Mo	Si	Cu	Fe
ACI CA-15 CA 14	*11.5 - 14*	*1 max.*	—	*1.50*	—	—
ACI CB-30 CA 16	*18 - 22*	*2 max.*	—	*1.00*	—	—
ACI CC-50 CA 19	*26 - 30*	*4 max.*	—	*1.00*	—	—
ACI CF-8 CA 17S	*18 - 21*	*8 - 11*	—	*2.00*	—	—
ACI CF-8M CA 17SMO	*18 - 21*	*9 - 12*	*2.0 - 3.0*	*1.50*	—	—
ACI CH-10 CA 22S	*22 - 26*	*12 - 15*	—	*2.00*	—	—
ACI CH-10M CA 22SMO	*22 - 26*	*12 - 15*	*2.5 - 3.5*	*2.00*	—	—
CA FA-20	*19 - 21*	*28 - 30*	*3.25 - 3.75*	*1.5 max.*	*4.0 - 4.5*	—
CA MM	—	*67*	—	*1.00*	*28*	*3.0*
CA Ni	—	*98*	—	—	—	—

ACI—American Casting Institute designations.
CA—The Cooper Alloy Foundry Co. designations



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American Hard Rubber Co.

Materials Engineering File Facts

ADVERTISEMENT

NUMBER A-2
May, 1949

ACE MOLDED HARD RUBBER PARTS

MATERIALS: Hard Rubber

HARD RUBBER is a thermosetting plastic combining outstanding chemical, physical and electrical characteristics including low moisture absorption and excellent machining qualities. In many respects standard grades of hard rubber are superior to other plastics. Special grades can be compounded to possess certain properties to a high degree. By producing these special grades, we are enabled to bring the valuable advantages of hard rubber into a broad range of industrial applications.

TABLE OF PROPERTIES . . . MOLDED PARTS OF ACE HARD RUBBER

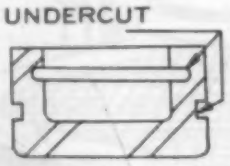
Grade Designation	Principal Characteristics or Uses	Tensile Strength Psi	Color	Elong. %	Sp. Gr.	Sclero Hardness	Rockwell Pen. Rec.	Flexural Strength MFS/Psi	Heat Distortion Temp. Deg. F.	Dielectric Strength 60 Cycles, v/mil.	Power Factor 1 Megacycle %	Dielectric Constant 1 Megacycle	Surface Resistance 74° F 86% R. H.	Water *Absorp. 48 hrs. at R. T.
Super Ace	General Purposes	8300	Black	4.00	1.21	72	108-76	12500	142	435	0.8	3.00	4.8×10^5	.08
Ace	General Purposes	7900	Black	4.00	1.21	72	107-91	11340	145	496	0.7	2.95	over 10^6	.06
Banner	General Purposes	4500	Black	3.40	1.28	55	129-79	7125	112	344	1.2	3.80	over 10^6	.14
Comet	General Purposes	2000	Black	2.00	1.54	30	103-27	2818	Low	377	2.8	4.95	5.08×10^5	.30
Resiston	High Heat Resistance	6750	Red-Brown	2.60	1.65	55	83-60	8675	283	393	1.2	4.10	5.32×10^5	.06
Magnon (Super Ace)	High Arc Resistance, Heat and Wear Resistance	4000	Red-Brown	1.00	1.95	54	65-41	8400	300	600	2.5	4.80	Arc Resistance 248	.06
Magnon (Ace)	Arc, Heat, Wear Resistance													
Hydron	High Dielectric Quality Heat Resistance,	5800	Red-Brown	2.60	1.71	59	82-55	9060	246	371	1.2	4.60	4.46×10^4	.10
	Low Moisture Absorption	5400	Black	1.80	1.80	56	82-54	10000	295	420	1.8	4.10	8.02×10^4	.04

*Representative (average) values

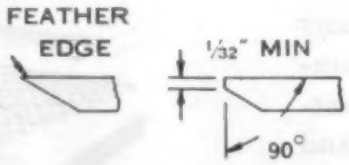
Figures given are based on standard A.S.T.M. tests.

DESIGN DETAILS:

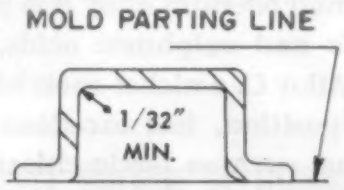
Good molding practice requires that the Design Engineer follow closely the recommendations below to insure a successful result.



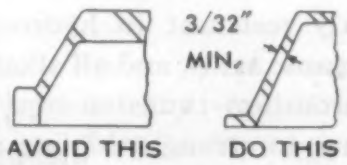
Undercuts usually cheaper to machine than to mold



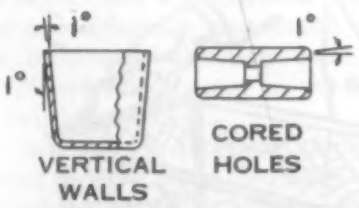
Avoid fragile edges; 1/32" is minimum



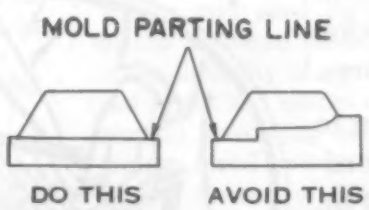
Large radii best. 1/32" is minimum. Avoid radii at parting line



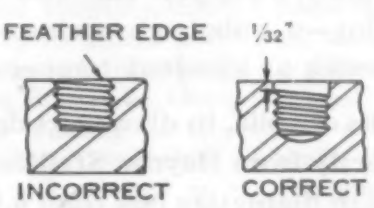
Keep sections light, uniform for short cure. 3/32" minimum



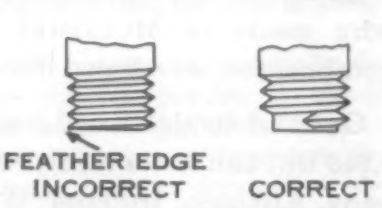
Facilitate removal of pieces and cores by at least 1° draft



Reduce mold and finishing cost by straight parting line

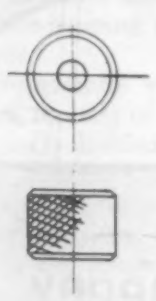


Prevent chipped threads; provide recess shown



Start male threads 1/32" from end

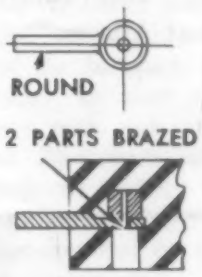
DESIGN OF INSERTS:



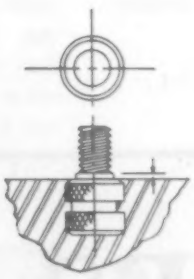
Coarse Diamond Knurl

Undercut flat inserts

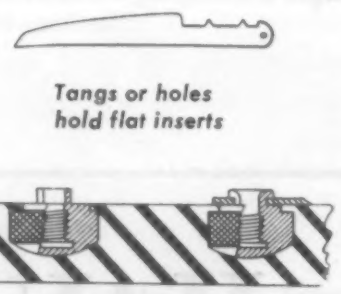
Undercut straight knurl or hex



Kurl only part imbedded. Round projection easiest to position in mold



Shoulder keeps rubber out of threads



Tangs or holes hold flat inserts

Attach strips by spinning over insert

ASSEMBLING INSERTS AFTER MOLDING: Soften the part on steam table or in water at 200°F. Press insert into hole. Rubber shrinks, hardens, grips tightly. Make hole 0.003" to 0.006" smaller than insert.

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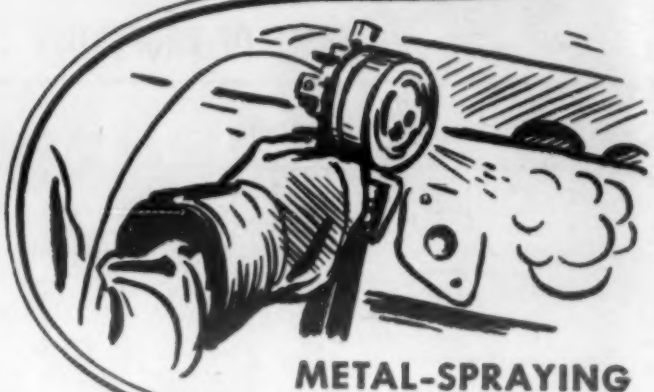
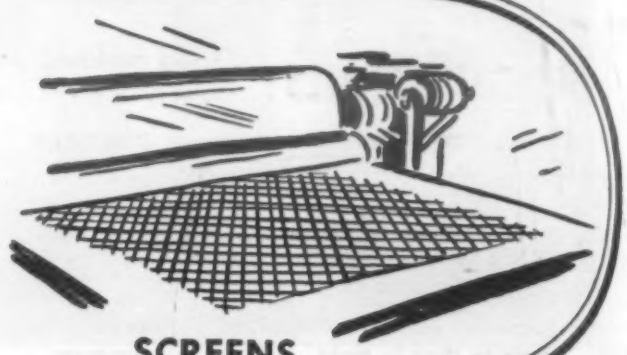
TRADE-MARK

FOR METAL-SPRAYING, WELDING, and FABRICATED WIRE PRODUCTS

"UNIONMELT" WELDING



METAL-SPRAYING



SCREENS

HEAT-TREATING BASKETS

HASTELLOY nickel-base alloys, in the form of drawn wire, are available for the fabrication of corrosion-resistant screen, cloth, and baskets. The wire is also excellent for metal-spraying and for many types of automatic welding and hard-facing.

HASTELLOY alloys have a tensile strength comparable to that of the high-strength alloy steels, and possess unusual strength even at elevated temperatures. These alloys are specially designed to withstand the most severe conditions of chemical corrosion. Nickel-molybdenum alloy B is particularly resistant to hydrochloric and sulphuric acids, many organic acids, and all alkalies. Alloy C, a nickel-molybdenum-chromium-tungsten-iron composition, has excellent resistance to strong oxidizing agents, such as ferric chloride and wet chlorine, and is outstanding in its resistance to brine and salt spray.

In addition to HASTELLOY alloy wire, you can also obtain wire made of MULTIMET alloy—a cobalt-chromium-nickel composition developed for service at elevated temperatures.

Cut and straightened lengths or coils, in diameters down to 0.060 in., can be obtained directly from Haynes Stellite Company, Kokomo, Indiana. Wire in diameters less than 0.060 in. down to 0.002 in. is available from an associate company, Kemet Laboratories Company, Inc., Madison Avenue and West 117th Street, Cleveland 1, Ohio. For more complete information, write for a copy of the booklet, "HASTELLOY High-Strength, Nickel-Base, Corrosion-Resistant Alloys."

HAYNES *alloys*
TRADE-MARK

Haynes Stellite Company
Unit of Union Carbide and Carbon Corporation
UCC
General Offices and Works, Kokomo, Indiana
Sales Offices
Chicago—Cleveland—Detroit—Houston
Los Angeles—New York—San Francisco—Tulsa

The terms "Haynes," "Hastelloy," "Multimet," and "Unionmelt" are trade-marks of Units of Union Carbide and Carbon Corporation.

MATERIALS & METHODS

DIGEST

A selective condensation of articles—presenting new developments and ideas in materials and their processing—from foreign journals and domestic publications of specialized circulation.

Edited by H. R. CLAUSER

Effects on Properties by Carbides in Steels

Investigations on the carbides present in steels have potential practical significance as well as theoretical interest, since a change in the type of carbide appears to affect many properties such as resistance to tempering and graphitization. Three recent German papers deal with this subject. The first, by W. Koch in *Stahl und Eisen* (German), Jan. 6, 1949, covers the method of isolation of the carbides and their study with the electron microscope.

In the Feb. 3, 1949 issue, W. Koch and H. J. Wiester consider further the carbides in alloy steels. The formation of alloy carbides in chromium, manganese and molybdenum steels is determined by the carbon and alloy contents as well as by the prior treatment. The alloy content of the carbide is higher in low carbon than in high carbon steels with the same alloy content. With sufficiently high alloy content, alloy carbides are formed when the steel transforms to pearlite, but generally cementite results on transformation to bainite or martensite. The carbides of chromium steels in the temper-brittle and unembrittled conditions showed no difference that could explain temper brittleness, although there was a higher phosphorus content in the carbides of the brittle specimens.

The cause of the increased resistance to tempering of steels containing alloy carbides is the subject of an article by the same authors in the same issue. At low tempering temperatures, only part of the carbon in quenched martensite is precipitated as cementite. As the tempering temperature increases, more cementite is formed but considerable carbon still remains in solution. The resistance to tempering is promoted by the carbide-forming alloy in solution in the martensite.

At temperatures where the alloy carbide can form, the rest of the carbon precipitates as very finely divided alloy carbides. Eventually, the cementite transforms to alloy carbides. The precipitation hardening, due to the alloy carbides, overlaps the softening caused by the coagulation of the cementite and may cause an actual increase in hardness with increasing tempering temperature or may merely partially counteract the softening that would be encountered with carbon steels. With further increases of the tempering temperature, the hardness again decreases as a result of the coarsening of the alloy carbide.

Sheath Working of Titanium Powders

While titanium has many promising properties such as high strength, light weight, and good corrosion resistance, one of the problems holding up its general use is the difficulty of producing it in commercial forms and shapes on a large scale. One method involving sheath working of titanium metal powder has been investigated by the *Bureau of Mines* and reported on recently (R.I. 4464).

In sheath rolling, the green but unsintered titanium powder is packed in sealed, ductile, gas tight containers, and heated to elevated temperatures. The assembly is then hot-rolled. The container protects the powder from harmful gases during the heating and working of the compact, and also confines the particles so that they are brought into contact with each other and plastically deformed. As a result, solid, nonporous metal is produced without need for long sintering operations at high vacuum or restriction in size imposed by the limitations of pressing equipment.

Limited tests to determine the properties of sheath worked titanium indicated that the titanium sheet produced in this way compares favorably with the standard product. It has a higher tensile and yield strength, about the same proportional limit, a lower elongation, and a slightly higher hardness. The most significant of these differences is the low elongation; this, however, does not appear to be too serious, since the sheet is capable of being cold-rolled to 40% reduction, the same as standard sheet.

Although the process was originally developed for titanium powder, it should have a wide range of application to practically all metal powders or fragments. Experiments were made to demonstrate the feasibility of the process on representative metal powders, including chromium, tantalum, tungsten, molybdenum, beryllium, cobalt, iron and nickel. Large metallic fragments, such as zirconium scrap turnings and pieces of electrolytically deposited chromium, cobalt and manganese, were also treated by this method.

● J. K. Gustafson of the Atomic Energy Commission, in a talk at the *Massachusetts Institute of Technology*, said that he believes there is enough source material for extracting the necessary quantities of uranium to permit the atomic energy business to expand considerably and to go on for generations.

Type 430 powder cut diameter 3⅛" x 106½" OD x 16" ID with Notch 15" x 8". Weight 7645 lbs.

DIGEST

Sintered Powder Coal Parts

The Germans have made successful attempts to apply powder metallurgy techniques to the production of parts from powdered coal, according to an article in *The Engineers' Digest* (British), Mar. 1949. Based on German reports, the article describes the experimental pressing and sintering of very finely ground mixtures of bituminous and semi-bituminous coals. Compacts were prepared using several different mixtures; after pressing they were sintered at 1830 F for one hour, air being excluded.

Breaking strengths were obtained ranging from less than 1400 psi. to as high as about 3500 psi., depending upon the mixture and compacting pressure. The sintered coal compacts were ordinarily too brittle for machining with cutting tools; however, machining was possible when the compacts were treated with solutions of alcohol and camphor, or benzene and camphor.

It appears that the Germans intended to use sintered coal compacts for crucibles in place of Siemens-Plania graphite for sintering hard metal carbides. The sintered coal combines high specific resistance with good machinability for this purpose. Mention was also made of the use of sintered coal parts as bushings.

Advantages of Full Hardness Quenching

A newly-published report of the *Society of Automotive Engineers*, "Physical Properties as Influenced by As-Quenched Hardness," goes a long way toward settling the controversy over the degree of sub-surface hardening needed to get adequate physical properties in a steel part. It shows that full as-quenched hardness develops greater physical properties.

There have been two schools of thought on this subject. One group believes the part must be hardened all the way through (getting complete transformation from austenite to martensite) to do the best possible job; the other feels lesser amounts of hardening are adequate to do the job. Investigations reported in this new publication—based on tests with three different kinds of steels—tend to support the first group.

Since design stress almost always is based on yield strength values, says the report, it seems especially desirable to get the full as-quenched hardness of which the steel being treated is capable. There seems to be no significant difference in elongation or reduction of area with respect to a change in as-quenched hardness. But if any generali-

DIGEST

zation were to be made, elongation and reduction of area tend toward slightly higher values as-quenched hardness is increased.

Impact strength also increases as the quenched hardness is increased. Impact strengths of the three steels at equal hardness values differ considerably. Difference in microstructure of the as-quenched blanks may partially explain this behavior. Photomicrographs (of which there are 22 in the report) picture this difference in structures of the three grades of steel at equal hardness.

Analysis of the photomicrographs seem to show that a duplex structure—composed of high and low transformation products—tend more toward brittle failure than a duplex structure of lower bainite and martensite, constituents formed at relatively low temperatures. Shot peening of partially hardened structures cannot be relied on to replace complete hardening to bolster resistance of steel, the investigation showed.

Heat Radiation Pictures Made with Phosphor Compounds

Pictures made with heat radiation is now possible by a method developed by Eastman Kodak Co. The new technique was reported on by F. Urbach before the *Optical Society of America*. The method, which is expected to have many applications in science and industry, uses highly sensitive phosphors to record the heat of objects over a wide range of temperatures. A screen is coated with the specially prepared phosphors. Then through the use of a curved metal mirror, the heat radiation of an object is focused on the screen and can be examined under ultraviolet light, or can be photographed.

By measuring the brightness of the phosphor, the temperature at many points can be measured simultaneously. Since all radiation produces a little heat, it is theoretically possible to record many things with refinements of the heat radiation technique.

Chemical Brightening of Aluminum and Its Alloys

Electro-brightening and electro-polishing treatments for aluminum have been used on an increasing scale since 1933. Certain difficulties have arisen with these processes, notably the need for auxiliary cathodes for deep reflectors, the shading produced on closely packed articles and reflectivities of the treated products under 75%. A solution

DIGEST

to these problems appears to be a new method involving chemical treatment without the use of applied electric current.

The British chemical brightening treatment (Alpol) is covered by V. F. Henley in the Feb. 1949 issue of *Sheet Metal Industries* (British). Independent research in the U.S.A. has resulted in the development of similar processes but with the added advantage that an extended range of alloys can be used.

The final result depends on the original surface. It is advisable to remove deep scratches by scratch brushing, grease mopping, shot blasting or chemical etching. After this preparation, the aluminum is degreased, then dipped for 1 to 2 min. in the bright dip solution (no composition given) and rinsed. The brightened surface can be dried and used without further preparation or it can be rendered permanent by subsequent anodic oxidation and sealing, or by coating with a clear lacquer.

Material with a poor surface finish can be smoothed out by a longer preliminary treatment in a special bright dipping solution. The brightest finishes are produced on high purity aluminum, although the results on commercial quality aluminum are sufficiently good for all but the most exacting requirements.

Chemical brightening gives total reflectance factors on grease mopped commercial quality aluminum that slightly exceed those previously obtained by electro-brightening. The British Ministry of Supply has approved the process since samples of super-purity aluminum examined by them had 8% higher total reflectivity than that usually obtained. The process has been used commercially on various types of articles, including reflectors, architectural metal work, furniture, instrument parts, and jewelry.

● In a recent talk before the *Pittsburgh Science of Metals Club*, L. A. Carapella, of the *Mellon Institute of Industrial Research*, showed how through the action of four basic factors, an alloy composition can be selected to fit a given set of physical requirements and how properties can be predicted from composition. Rapid strides have been made, particularly over the past 25 years, in the quest for a basic understanding of the complexities of metallic behaviors. He asserted that if we continue to think along these lines and explore our notions diligently and scientifically in a concerted manner, it is quite possible that a common denominator will eventually be uncovered, thereby simplifying the prevailing concepts of alloying behaviors.

DIGEST

Heat-Treatment of Steel in a Magnetic Field

At the present time, interest is being shown in heat treating steel under the effect of magnetic fields. Since much of the previous experimental work is not generally known, it is briefly reviewed by J. F. Kayser in the Winter 1948-1949 issue of *Metal Treatment* (British).

As long ago as 1897 attempts were made to quench magnets while they were subjected to a magnetizing force, but the gain in magnetic properties did not seem to be sufficient to warrant the trouble. Later, the maximum permeability of silicon transformer steel was sometimes increased as much as 50% by treatment in a magnetic field during annealing at about 1275 F. Iron-cobalt-nickel alloys in the gamma phase were found to be particularly susceptible to heat treatment in a magnetic field.

The maximum permeability could be greatly increased, provided the Curie point was higher than about 930 F. A marked increase in the maximum permeability of iron-nickel alloys in the direction of the field applied during cooling was reported. The effect was directional, with the transverse permeability less than one-fourteenth that in the longitudinal direction.

In 1938 one investigation found that the effect of cooling nickel-aluminum-iron permanent magnets in a constant magnetic field was slight. Similar work on aluminum-cobalt-nickel-iron alloys was more fruitful and led to an improvement in BHmax of 100 to 200%, thus giving values of four to five million.

The author believes that ultimately a single theory will explain the magnetic properties of all ferromagnetic materials and how they are modified by heat treatment in a magnetic field. Many theories have been built around the internal strain concept. Such an explanation seems to have promising possibilities. It is felt that it may be provisionally accepted that magnetic properties depend in part on the state of internal strain.

Cold Extrusion of Steel

New data on the cold extrusion of steel is given in a report issued by the *Office of Technical Services*, Department of Commerce. The report says that in many cases the cold extrusion of steel is expected to replace extruded and drawn nonferrous products as well as ferrous castings.

A section of the report deals with the de-

DIGEST

velopment of efficient, automatic phosphatizing (bonderizing) techniques. Phosphatizing, the application to steel of a lubricating finish for cold extrusion, is the key to the success of this process.

Tests indicated that cold extrusion could not only substantially reduce the cost and time necessary for the production of many parts, but also could improve their mechanical properties and result in a saving of metal. It is suggested that many items could be redesigned for more efficient production by cold extrusion without impairing their usefulness.

Properties and Uses of Manganese Iron

During the war, development work was carried out in Great Britain on a manganese iron that was a suitable substitute for austenitic manganese steel but that could be made in iron rather than steel foundries. P. F. Hancock, in *Foundry Trade Journal* (British), Feb. 3, 1949, discusses the properties and productions of the manganese iron with particular consideration of industrial applications.

The basic composition is 3 to 3.5% carbon and 12 to 15% manganese. The castings are given a decarburizing anneal at 1920 F, followed by a water quench from 1830 to 2010 F. The time for decarburization ranges from about 5 hr. for an ⅛-in. section to 55 to 70 hr. for a ½-in. section. The properties are generally similar to those of cast austenitic manganese steel, with a little lower strength and ductility and somewhat higher wear resistance. The surface hardness as annealed is about 250 to 300 Vickers, but it increases rapidly with cold working to 600 to 650 Vickers. After annealing, the surface layers are a mixture of austenite and martensite, but the core is austenitic.

The basic manganese iron is suitable only for castings of fairly regular section not exceeding ¾ in. For heavier sections, there is a graphitizable modification with about 3 carbon, 2 silicon, 10 manganese and 3% nickel. A decarburizing anneal of 40 hr. at 1920 F decarburizes the surface, while the core graphitizes sufficiently to give reasonable ductility.

Production costs should be roughly the same as for blackheart malleable iron, while the raw material costs will be somewhat greater. The probable field of application coincides with that of austenitic manganese steel castings as the principal characteristics are similar—high toughness and exceptional wear resistance. A disadvantage is that, like

DIGEST

manganese steel, it is machinable only with hard-metal tools.

The straight manganese iron would be used for sections up to about ½ in. and the graphitizable type for heavier sections up to about 2 in. It is likely that manganese iron might displace whiteheart or pearlitic blackheart malleable in some applications, such as parts for agricultural implements, where improved wear resistance at a slight extra cost would be advantageous.

•

● Detecting a flaw 1/500-in. wide in a boring 35 ft. long can now be accomplished with a new technique developed in *General Electric's Schenectady Works Laboratory.* Examining the inside surfaces of holes bored in long metal forgings makes combined use of fluorescent lights, a mirror, and a surveyor's telescope. The forging is first magnetized and iron oxide particles are blown down the hole. These particles align themselves with the north and south magnetic poles of any cracks or flaws which are present. Then a small cylinder on which three fluorescent tubes and a small mirror have been mounted is drawn slowly through the hole. As the cylinder moves through the boring the surfaces reflected in the mirror are examined through the surveyor's telescope. Flaws in the forging, outlined by the iron oxide particles, are then visible.

Photosensitive Glass

Photosensitive glass has recently been developed to a commercial stage at Corning Glass Works. Details of this new type glass that makes it possible to print colored photographic images within glass articles are given in an article by S. D. Stookey appearing in *Industrial & Engineering Chemistry,* Apr. 1949.

Photosensitive glasses are very similar to certain conventional glasses in composition, except for minute additions of photosensitive metals, optical sensitizers, and thermoreducing agents. The glasses possess a unique combination of properties such as permanence, durability, transparency, and other glass qualities.

Their lack of grain makes them suitable for applications requiring extremely high resolving power, such as scales or reticles in optical instruments. Their heat resistance, durability, dimensional stability, and other characteristics fit them for industrial uses such as instrument dials, patterns, pushbuttons, and signals. Photosensitive glass can also be used for tableware, jewelry, or lighting units.

New Materials and Equipment

Two-Chamber Induction Melting Furnace Improves Metal Quality

A new development in induction melting furnaces, referred to as "channel flushing," has been announced by the *Fisher Furnace Div., Lindberg Engineering Co.*, 2444 W. Hubbard St., Chicago 12. This is a further development of the two-chamber induction melting furnace announced by the company in 1947.

Channel flushing is said to always keep the channels between the two chambers clean and free of slag or oxide accumulations. The primary coil of the furnace transformer is located in a manner to cause a greater volume of molten metal to be impelled into one chamber than the other. This raises the molten metal level in the one chamber, and lowers the level in the other chamber. Every 60 sec. when the power is cut off, the higher level subsides, and the molten metal flows to the other chamber until the same level exists in both chambers. When the current is restored, the molten metal is forced in the opposite direction, again causing a higher level in the one chamber than the other.

The furnace control equipment automatically interrupts the power once a minute; thus, the channel flushing takes place twice a minute. The flushing that occurs when the power is interrupted is the more important of the two flushings, because impurities and dross are released from the magnetic field surrounding the channels that connect the two chambers.

The constant, flushing, stirring and mixing action insures metal of uniform analysis and also causes a beneficial fluxing action.

View of the two-chamber induction melting furnace that uses "channel flushing."

New Non-Silicated Cleaner for Metals

A non-silicated soak or electrocleaner especially suitable for applications where the presence of a silicate in the solution would interfere with subsequent processing has been developed by the *Hanson-Van Winkle-Munning Co.*, Matawan, N. J.

Designated No. 25-W, it may be used as a soak or electrocleaner on steel, copper, brass, lead-base castings or die castings. Reverse electrocleaning can be used on steel to secure smut-free surfaces. The concentration recommended is 3 to 8 oz. per gal. The higher concentrations are recommended for steel.

Temperature range is 160 to 200 F. Immersion time for soak cleaning is 3 to 5 min. Immersion time for electrocleaning is 30 sec. to 3 min. Current density for electrocleaning is 20 to 50 amp. per sq. ft. The higher range is used for steel and copper; the lower for brass, lead-base coatings and die castings.

New Materials and Equipment
(CONTINUED)

Radiant Gas Heating Used for Silver Brazing

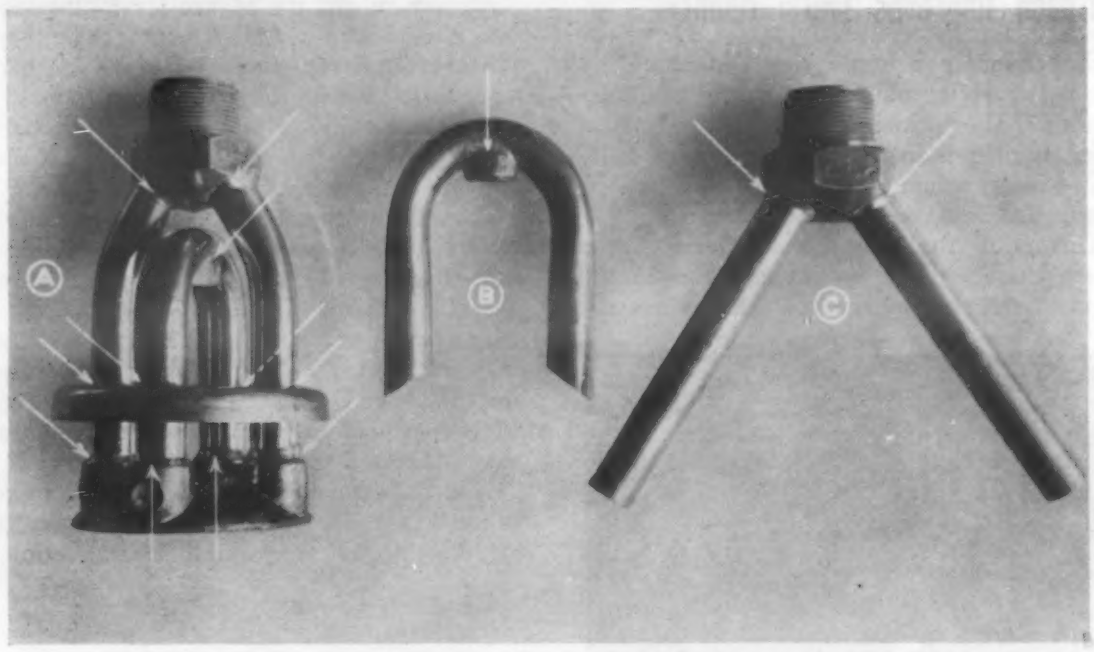
A special purpose, automatic radiant gas heating machine has been produced by the *Selas Corp. of America,* Erie Ave. & D St., Philadelphia 34, for silver alloy brazing of brass sub-assemblies. The machine brazes 11 joints on 540 units per hr. Seven joints brazed simultaneously are gas-tight; four support joints are brazed simultaneously.

The machine has 46 ceramic gas-air burners, each of which is adjustable with additional heat control provided at the four-burner manifolds. The two turntables are controlled by a variable-speed drive, synchronized exactly to the requirements of heating time and gas volume.

Pre-mixed gas and air are supplied to the machine in proper proportions for complete combustion and at constant pressure by a combustion controller. The combustion system is equipped with automatic fire checks.

The fuel requirements of the machine are estimated at 350 cu. ft. of 1000 B.t.u. natural gas per hr. Fuel economy is illustrated for this machine with an assumed natural gas price of 50¢ per 1000 cu. ft.: 18.4¢ per hr. or 35¢ per 1000 brazed units. The over-all dimensions of the machine are: 4 ft., 6 in. wide, 6 ft., 6 in. long, and 4 ft., 6 in. high.

This method of joining metals has the operational flexibility that permits its application to standardized units of production and to units that are changed frequently.



Assembly silver brazed with radiant gas heat. A, completed unit; B and C, components.

New Chromate Metal Primer Is Quick Drying

A quick drying chromate metal primer has been developed by the *Tremco Manufacturing Co.,* 8701 Kinsman Rd., Cleveland. With this priming treatment it is possible to apply two coats of paint over metal in a single day. The priming coat dries to touch in 10 min. and may be handled in 20 min. It can be re-coated in 30 min. to an hour, under average conditions of temperature and humidity, even with coatings containing strong solvents—without danger of the primer's lifting or blistering. Because of its very fast drying action, this primer allows a finish coat to be applied without time loss or using excessive labor.

This quick drying chromated metal primer and one finish coat are said to provide a very durable film over metal surfaces, and maximum life to paint coats on all types of metal surfaces are advantages of this treatment. In addition to sealing the surface from moisture, this priming coat prepares the metal surface so that paint or enamel adheres firmly.

The primer is a Bakelite type of coating; it does not require oxidation to dry; by evaporation of the solvents, it forms a tough, inert film which retains its flexibility. The primer has good adhesion to light metals as well as to steel, and is resistant to salt spray, moisture and corrosive atmosphere. It is furnished in both red and neutral gray, and can be applied by either brush or spray.

New Developments in Nonmetallic Materials

Acrylic Sheets

A new process for the manufacture of heavy plastic pearlescent acrylic sheets has been announced by the *Acryvin Corp. of America,* 18-12 Astoria Blvd., Astoria, N. Y. This new development permits the manufacture of sheets that are 3 ft. wide and 4 ft. long, ranging from ½ to 1½ in. in thickness. These sheets will be available in eight different colors: white, gold and black, azure blue, baby blue, emerald green, ruby, baby pink and black pearl.

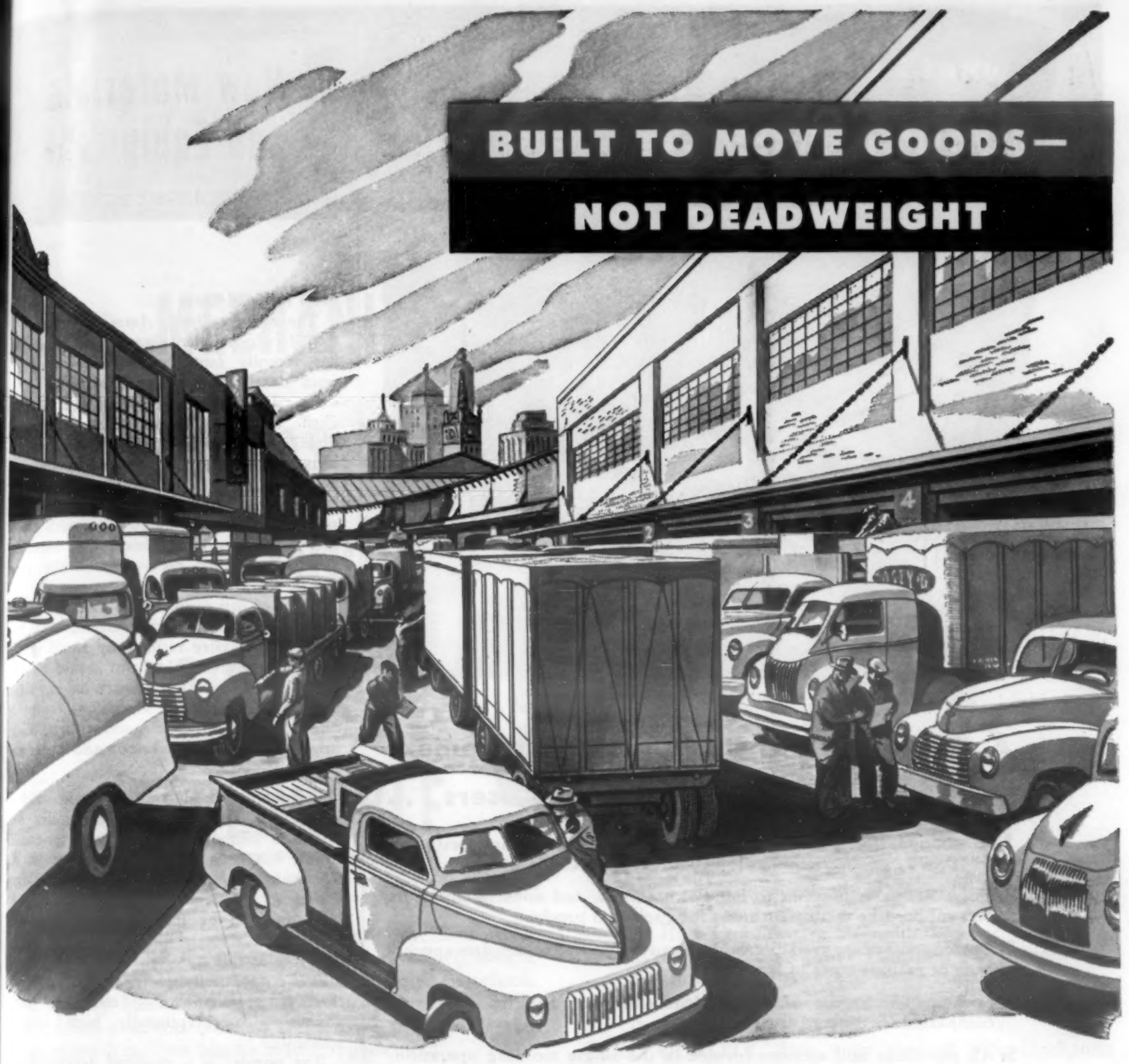
Polyester Resin

A new polyester resin that is nearly water white has been announced by *United States Rubber Co., Naugatuck Chemical Div.,* Naugatuck, Conn. It makes possible clear color casting and impregnating work which has heretofore been possible for the most part only with thermoplastic materials.

Known as Vibrin 108, the new thermosetting resin is said to permit decorative work with clear color and high color retention. Its low water absorption favors its use in out-of-doors applications.

When a peroxide catalyst is used, curing takes place at medium temperatures. Cures may be initiated at lower temperatures when promoters or low-temperature catalysts are used. It is adaptable to continuous laminating or to casting wherever the best color retention is required.

The plastic has a specific gravity of 1.25, a tensile strength of 12,000 psi., and an elongation of 6%. Its hardness is Rockwell M-110. Some of its uses include decorative laminates, clear castings and bag or matched die moldings by simple low pressure methods.



The weight's in the load and not in the truck when frames, body panels, fenders, wheels and other truck structural parts are made of N-A-X HIGH-TENSILE. And while affording weight savings of up to 25% in section, the high physical properties of N-A-X HIGH-TENSILE insure superior strength and increased resistance to fatigue, corrosion, abrasion and denting.

This decrease in deadweight decreases on-the-job expenses, too. Trucks built with N-A-X HIGH-TENSILE consume less gasoline . . . require less maintenance . . . give longer service. And the excellent formability, weldability, and fine surface texture of N-A-X HIGH-TENSILE mean that you build them better, with no added fabricating problems.

MAKE A TON OF SHEET STEEL GO FARTHER
Specify—
N-A-X
HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION
N-A-X ALLOY DIVISION • DETROIT 18, MICHIGAN
Unit of National Steel Corporation

New Materials and Equipment

Resin for Sand Cores

The *Plastics Dept., American Cyanamid Co.,* 30 Rockefeller Plaza, New York 20, has recently introduced a new synthetic resin developed for the binding of sand cores. It is a thermosetting resin called Cycor 151, made under controlled conditions and especially prepared as a water resistant foundry core binder. It contains no filler or additives of any kind. The foundry may vary the amount of resin and/or additives to obtain cores with green and baked tensiles, permeability, hardness and collapsibility necessary for the type casting to be made.

Cores of this resin can be cured in either conventional or dielectric ovens, and because it is a pure resin, only small quantities are required. The resin is said to give foundries 33% to 50% faster baking time than old-time binders at baking temperatures of 350 F. The good collapsibility insures savings in shake-out and cleaning

Rubber Powder

Commercial production of nitrile rubber in powder form, designed especially for mill and Banbury blending with phenolic resins, has been announced by the *B. F. Goodrich Chemical Co.,* 324 Rose Bldg., Cleveland 15. Known as Hycar OR-15, it is claimed to be the first finely divided elastomeric material to be commercially available in this country. The development makes economically feasible the manufacture of rubber-phenolic molding compounds with exceptionally high impact resistance.

The powder is a modified acrylonitrile-butadiene copolymer which serves as the basic material in a variety of products. It has high resistance to oil, abrasion and high temperature. Heretofore supplied in two basic forms, dry sheet rubber and latex, it is now also available in the new powder form in production quantities.

Nitrogen Filled Rubber

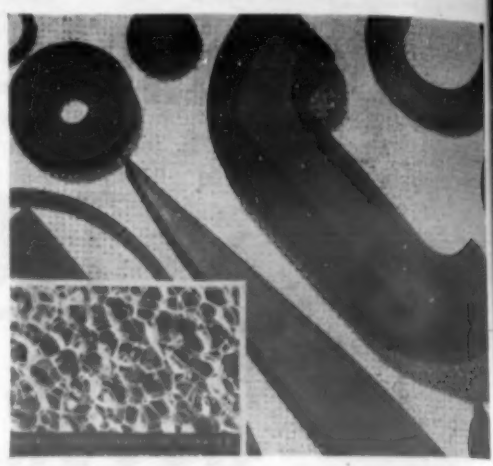
Now available for general use in industry is the gas-expanded closed-cellular rubber developed by *Rubatex Div., Great American Industries, Inc.,* 230 Park Ave., New York 17. Unlike sponge rubber, in which the air spaces are interconnected, this material, known as Rubatex, is composed of minute cells, each individually encased in a wall of rubber. The cells are filled with inert nitrogen. Because there is no escape of the nitrogen, or interchange between the cells, this product possesses good resilience, thermal non-conductivity, light weight, and buoyancy. Its moisture absorption is practically zero.

Low conductance of heat makes this material an ideal insulator for use in stationary and portable refrigeration equip-

New Materials and Equipment

ment. Many possible applications to electrical insulation will be apparent. Uses in marine and aviation equipment also will be influenced heavily by the permanent buoyancy of the material on water.

This material can be molded, in the manufacturer's plant, to the desired shape, or may be worked by the fabricator through die-cutting, stamping, splitting, cementing, or other conventional methods. It is obtainable in sheet form, up to 1-in. thickness, which can be laminated for greater depth, and is offered in either natural or synthetic rubber, in a wide range of colors.



Some products produced of gas-expanded closed-cellular rubber.

Spray Finish for Plastics Requires No Oven

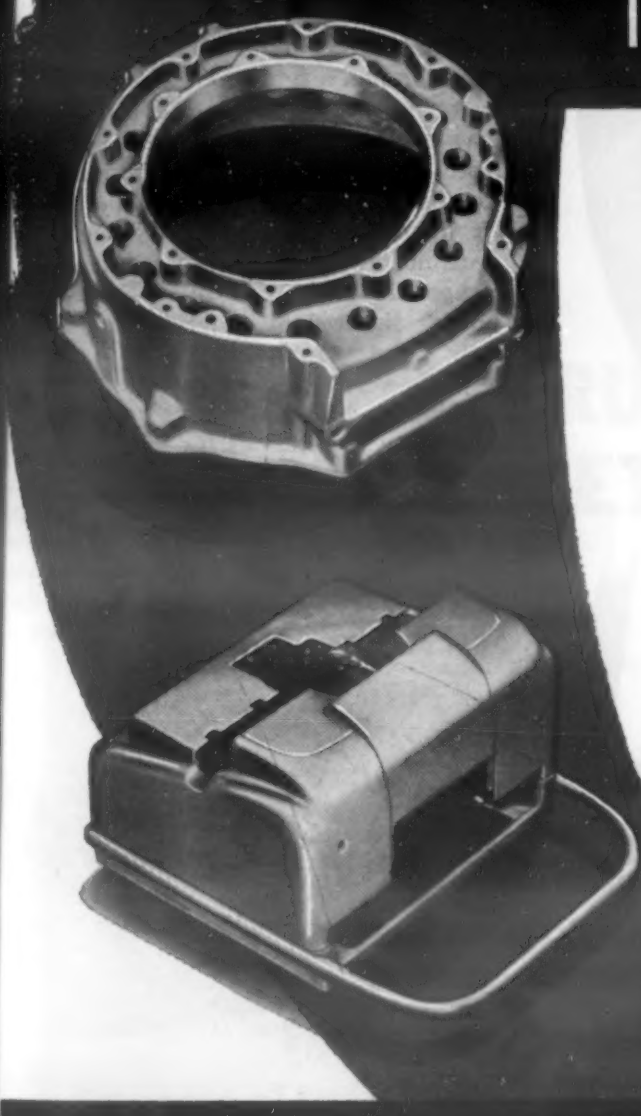
An improved form of a spray treatment for polystyrene surfaces has been announced by the *Bee Chemical Co.*, 13799 S. Avenue 0, Chicago. The new finish is available either as a clear material or with pigments providing a wide choice of colors.

The material is said to preserve the advantages of the original treatment but eliminates the characteristics that made the former product somewhat difficult to use. Surface hardness and brilliance have not been sacrificed, but new developments make the material very easy to spray with any conventional equipment. Sensitivity to humidity has been so greatly reduced, according to the manufacturer, that clouding does not occur under any ordinary conditions, and it is unnecessary to force dry the sprayed parts unless for production reasons.

The pigmented finish has many uses. For example, with it a producer can accomplish a variety of color treatments with a single run of material.

TAKE THE DEAD WEIGHT OUT OF YOUR PRODUCT WITH

"DOLER-MAG"* MAGNESIUM



YOUR PRODUCT could be a design success story like these!

SCINTILLA DISTRIBUTOR HOUSING FOR AIRCRAFT ENGINES

Lightness plus our ability to cast the many holes determined the use of "DOLER-MAG" die casting in this operation.

8½" Diameter x 3⅛" High. Weighs—1.85 lbs.

●

UNDERWOOD ELECTRIC TYPEWRITER *(Assembled)*

The number of magnesium die castings used in this unit reduce weight and provide necessary stiffness and rigidity. Damping capacity effectively reduces vibration and operational noise.

Six parts—Total Weight 4.573 lbs.
Equivalent steel parts weigh 4 times as much.

*Reg. U.S. Pat. Off.

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New Materials and Equipment

Gage Measures Coating Thicknesses

An instrument for measuring the thickness of non-magnetic coatings on iron or steel has been announced by *Branson Instruments, Inc.*, 436 Fairfield Ave., Stamford, Conn. Measurements are made without damage to the coating, and the thickness is indicated directly on the meter of the instrument. Two concentric scales cover a range of 0.0001 to 0.50 in. The instrument's lightweight and self-contained battery power supply permit its use in the field as well as in the laboratory or on the production line.

Typical applications for the gage include the measurement of the thickness of paints, enamels, metal plating, protective coatings, scale or coke deposits. Thickness readings are within 10% of the actual thickness.

The gage head contains a coil, connected to a bridge circuit. Coating thickness is measured by the effect of changes in the reluctance of the magnetic circuit. When the coil is in direct contact with the base metal, the reluctance is low and the self-inductance of the coil is high. The bridge is then balanced for zero thickness. An increase in the gap between the coil and the base metal unbalances the bridge, and causes current to flow through the indicating microammeter.

This thickness gage measures non-magnetic coatings without damage.

Optical Pyrometer Has Lengthened Scale

An optical pyrometer designed for taking temperature readings of the limited range required for molten ferrous metals has been developed by *Pyrometer Instrument Co., Inc.*, Bergenfield, N. J.

The reading scale has been lengthened over 40% and covers only the critical

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WITH CELANESE* EXTRUDED ACETATE SHEET?

Substantial savings are possible with the new Celanese extruded acetate sheet.

SAVINGS IN FIRST COSTS—Celanese extruded sheet sells for considerably less than acetate and nitrate sheet made by the old solvent or block method.

SAVINGS IN PRODUCTION—Celanese extruded sheet is supplied in a variety of widths and lengths—to fit your blanking out requirements, and reduce cutting waste.

SAVINGS IN INSURANCE—Celanese extruded sheet is rated non-hazardous by the Underwriters' Laboratories . . . requires no special handling and storage . . . reduces insurance premiums.

Celanese extruded sheet can be heat formed, drawn, blown, fabricated and cemented by all standard methods. It is available in thicknesses from .003" and up—in a range of colors: transparent, translucent and opaque. Get in touch with your Celanese representative for up-to-the-minute information on how you can adapt extruded sheet to your needs.

Celanese Corporation of America, Plastics Division, Dept. 2-E, 180 Madison Avenue, New York 16, N. Y.

A Celanese* PLASTIC

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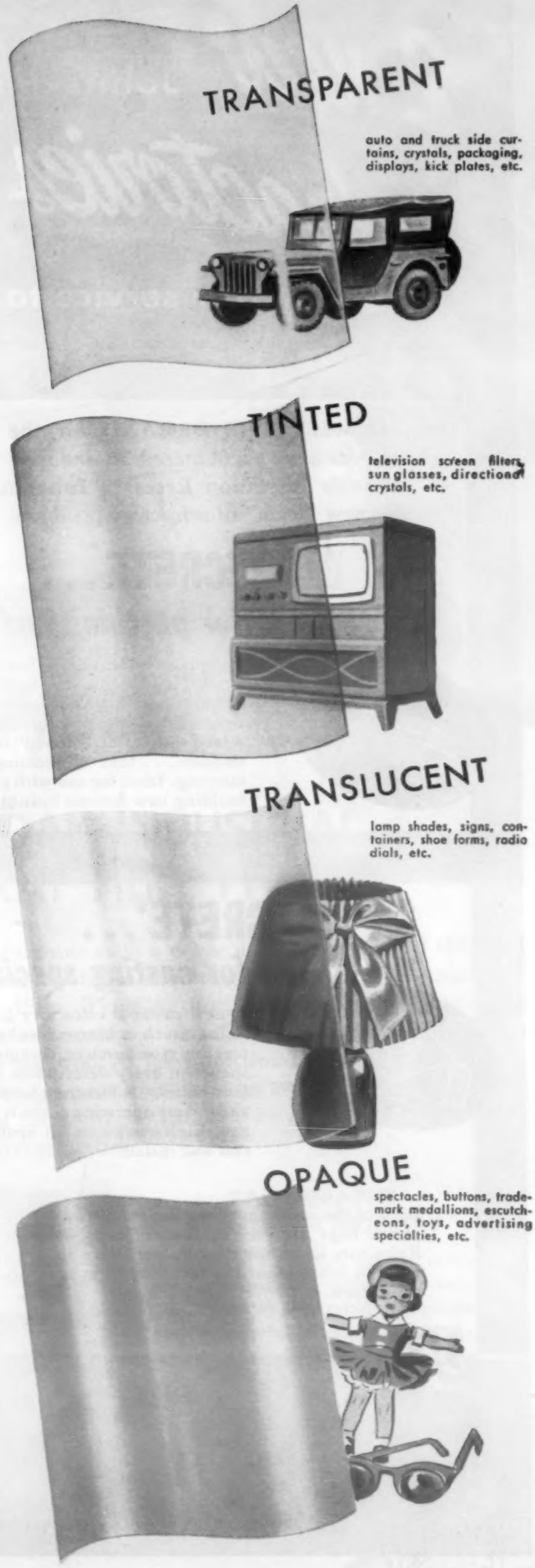


New Materials and Equipment

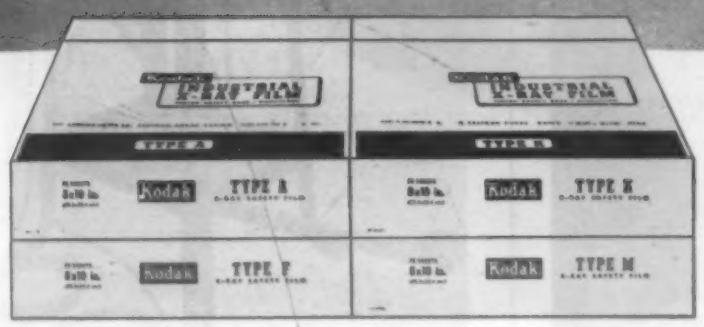
This optical pyrometer is particularly useful for readings on molten ferrous metals.

portion of the temperature range required. As a result, the standard temperature scale for black body conditions permits coverage from 2200 to 3000 F, and an additional scale in red, corrected for the emissivity of molten iron, steel, Monel, etc., reads from 2400 to 3300 F. Both scales are subdivided into 10-deg. divisions so that actual temperature readings can be made to within a very few degrees.

The black body scale is particularly desirable for measuring temperatures of furnaces, ovens, linings, fire boxes, etc., whereas the red scale permits direct readings of spout, pouring and ladle temperatures of molten iron, steel, Monel and other ferrous alloys.

WHAT'S THE RIGHT X-RAY FILM?

Answer:



KODAK INDUSTRIAL X-RAY FILM, TYPE A

A TYPE OF FILM FOR EVERY PROBLEM

To provide the recording medium best suited to any combination of radiographic factors, Kodak produces four types of industrial x-ray film. They provide the means to check welds efficiently and thus extend the use of the welding process.

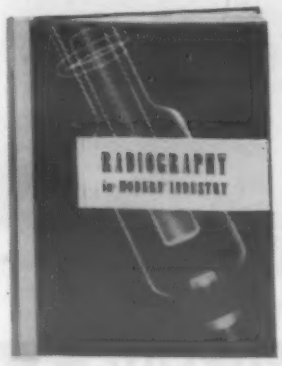
Type A—has high contrast with time-saving speed for study of light alloys at low voltage and for examining heavy parts at 1000 kv. Used direct or with lead-foil screens.

Type M—provides maximum radiographic sensitivity, under direct exposure or with lead-foil screens. It has extra-fine grain and, though speed is less than in Type A, it is adequate for light alloys at average kilovoltage and for much million-volt work.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays, exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

● To examine such a dense and thick material the radiographer takes advantage of Kodak Industrial X-ray Film, Type A. For, in order to keep exposure reasonably short, the high speed of this film is essential. At the same time, its high contrast and fine graininess enable him to take full advantage of the ability of the 1000 kv machine to detect weld irregularities.



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and technics. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get your copy from your local x-ray dealer—price, $3.

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New Materials and Equipment

Three New Welding Machines

Recently developed by the *Delta Manufacturing Div., Rockwell Manufacturing Co.*, 600 E. Vienna Ave., Milwaukee 1, Wis., are three new welders: a combination spot and arc welder; a 5-Kva. spot welder; and a portable 120-amp. arc welder.

The combination welder is 14 in. wide 19¾ in. high and 26⅜ in. long. It is especially suitable for use in maintenance

This combination welder can be used for either spot or arc welding.

and repair departments of factories, in experimental laboratories, in research departments, and in radio, electric, electronic and other light metal fabrication industries. The unit spot welds, arc welds, solders and brazes. Its 10-in. throat depth permits spot welding to the center of a 20-in. sheet.

The 5-Kva. spot welder is designed for manufacturing plants, light fabrication industries, sheet metal contractors, and other shops and places where proper current is available. This welder delivers a maximum of 7000 amp., operates on 230 v., single phase, 50/60 cy. a.c., and will weld at a production rate of 2 pcs. 16-gage clean mild steel.

Operated on a reduced voltage of 115 v., the spot welder's output reduces sufficiently to make possible the welding together of extremely fine wires without over heating or burning. In addition, this new spot welder can be converted to a fully automatic high production spot welder by adding air equipment and a weld timer.

The portable arc welder is rated at 120 amp. at 25 load v. It is a light duty limited-input transformer type welder. Its fast voltage recovery provides a steady arc,

USE CARBON!

Sales of "National" carbon mold plugs jumped nearly 50% in 1948 because:

1 With "National" carbon mold plugs, there is no contamination of ingot.

2 Carbon plugs will not stick to the ingot. They may be used more than once.

3 Carbon plugs are light, yet strong, so handle easily.

4 Carbon mold plugs are consistently accurate in dimensions.

5 Carbon's resistance to thermal shock and hot-metal erosion increases service life.

For more information, write to National Carbon Company, Inc., Dept. MM

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Canadian National Carbon Company Limited, Toronto 4, Canada

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Foreign Department: New York, U. S. A.

New Materials and Equipment

and the current has infinite adjustment be tween 30 and 120 amp. Constructed t stand maximum abuse, the transformer i protected against grounding out or short ing. The 65-v. open circuit secondary voltage makes for ease in starting arc, and the locking type jack receptacle facilitates easy removal of arc welding cable. It is mounted on removable casters and is easily portable.

● The *Champion Rivet Co.*, Harvard Ave. & E. 108 St., Cleveland 15, have announced their new 316-CF stainless steel electrode. This electrode has been developed to weld Type 316-ELC stainless steel, which is now produced in sheets, bars and plates. The unusual feature of this analysis is that the carbon content is the lowest that has ever been produced in stainless steel—0.03% max. With this small amount of carbon in the parent metal and electrodes, it is possible to practically eliminate intergranular corrosion in the zone adjacent to the weld and in the weld deposit because carbide precipitation is prevented.

Device Safeguards Combustion Conditions in Heating Equipment

A protective safeguard for gas and oil heating equipment, known as Flame-otrol, has been developed by the *Wheelco Instruments Co.*, Harrison & Peoria Sts., Chicago 7. The unit provides flame failure protection and has a range wide enough to monitor the flame safely without unnecessary shutdowns within the input capacity of the burner.

A Flame-eye with a blue photoelectric cell is the sensing element. The cell is highly sensitive to the blue and very insensitive to all other colors of the spectrum, and has the ability to, in effect, see only the light rays emitted by the flame. This characteristic permits the unit to distinguish between "flame-on" and "flame-off" conditions. It rejects other extraneous light rays originating from background sources.

The ability of the cell to determine if combustion conditions are safe permits the required amount of current to pass through the photoelectric cell and measuring circuit of the Flame-otrol, determining the control action necessary for safe operation.

you name it—

The new Airco 700 Welds It ...from thin metal to 2" plate

Why? Because this new torch is available with a selection of tip assemblies that range all the way from Size 00 through the large No. 10 size.

This wide tip selection makes the Airco 700 suitable for your welding work — from thinnest sheet metal up to sections 2" in thickness. When equipped with a multiflame tip, this torch is tops for silver and aluminum brazing.

Each welding tip is assembled with an individual mixer drilled for that particular tip. In addition to wide operating range, other features of the "700" are: better flame control ... perfect balance ... and low maintenance cost.

With the addition of a cutting attachment, the Airco 700 can be easily converted to handle general shop cutting work.

If you would like more information about this torch, or a free demonstration right in your own shop, address Dept. MA 8468, Air Reduction, 60 East 42nd Street, New York 17, N. Y. In Texas: Magnolia Airco Gas Products Company, Houston 1, Texas. On West Coast: Air Reduction Pacific Company, San Francisco 4, California.

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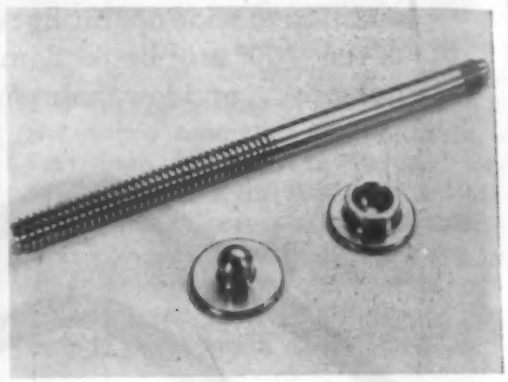
New Materials and Equipment

New Stainless Steel Alloy Now Available in Sheet and Plate Form

A new stainless steel introduced by the *Carpenter Steel Co., Alloy Tube Div.*, Union, N. J., about a year ago in various wrought forms is now being commercially produced in the forms of sheet and plate. Known as Stainless No. 20 sheet, it is produced in standard widths and lengths in gages from 24 to 11, while plate is being produced in thicknesses from 3/16 in. up.

Because of its excellent resistance to the corrosive effects of sulfuric acid, as well as many other substances, No. 20 is used in the manufacture of heavy chemicals, organic chemicals, synthetic rubber, high



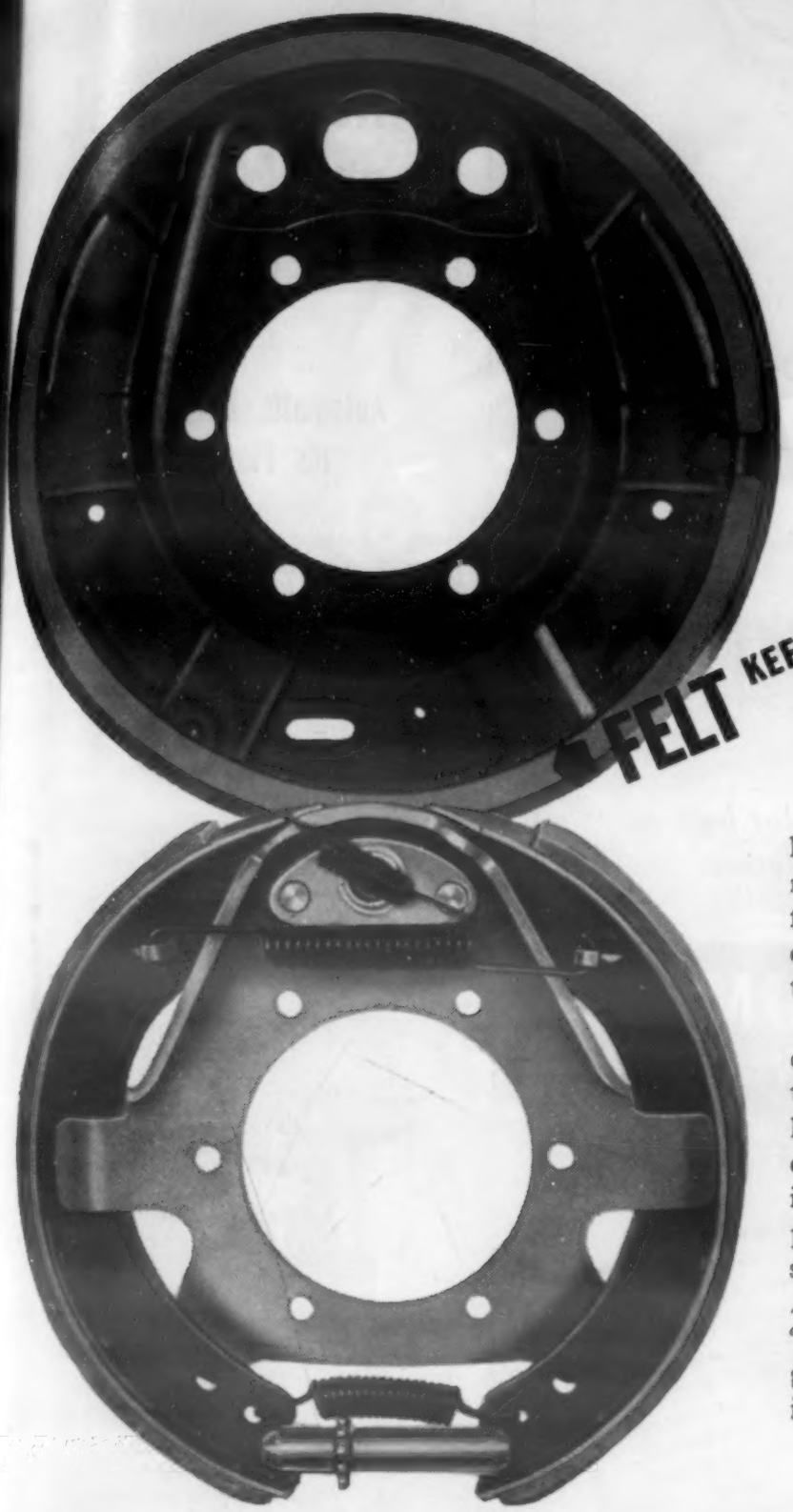
Typical parts made of the new stainless steel alloy.

octane gasoline, solvents, explosives, plastics and pharmaceuticals. Typical uses include pump shafts and rods, valve parts, screens, pipe lines, heat exchangers, fume ducts and exhaust fans, etc. The type analysis of the new alloy is as follows:

Carbon	0.07% max.
Manganese	0.75
Silicon	1.00
Chromium	20.00
Nickel	29.00
Molybdenum	2.00 min.
Copper	3.00

In addition to the high corrosion resistance provided by the alloy, it retains the good mechanical properties of the 18:8 stainless steels.

● A new simplified, self-aligning, unbreakable anode rod support is made of nonferrous metal covered with tough semi-hard rubber by *Automotive Rubber Co., Inc.*, 8601 Epworth Blvd., Detroit 4. The pin of the support sets in a hole provided in the tank flange. The support pivots to compensate for misalignment, and will support excessive loads and rods up to 4 in.



FELT KEEPS OUT DESTRUCTIVE DUST, RETAINS LUBRICANTS

Today, thanks to felt, farm tractors can plow and harrow in thick clouds of dust without damage. It was not always so; some of the early farm tractors were failures because their working parts were not adequately protected, and dust chewed up the engine, the bearings, the brakes.

Tractor manufacturers now have dust well under control, and American Felt Company is proud to help them, supplying felt for shields and seals that not only keep dust out of working parts, but also retain lubricants. Thus felt serves both industry and agriculture in several important ways. If your product requires protection against dust, dirt, water, or other substances, and must be reliably lubricated, write American Felt Company. Ask for Data Sheet No. 11, "Felt Seals, Their Design and Application", which gives authoritative technical information and includes illustrative samples.

● Bendix Mechanically-operated Farm Tractor Brake is an excellent example of the use of a felt seal to exclude dust. Top, dust shield showing felt seal in place. Bottom, inside view showing the new Centermount construction which eliminates the conventional backing plate.

American Felt Company

TRADE MARK

GENERAL OFFICES GLENVILLE, CONN.

ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.— PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal

VERSATILITY: Plain felt seals are cut by American Felt to your order, with a dimensional tolerance of .005". Laminated felt seals consist of plain felt combined with one or more impervious septums of Hycar.

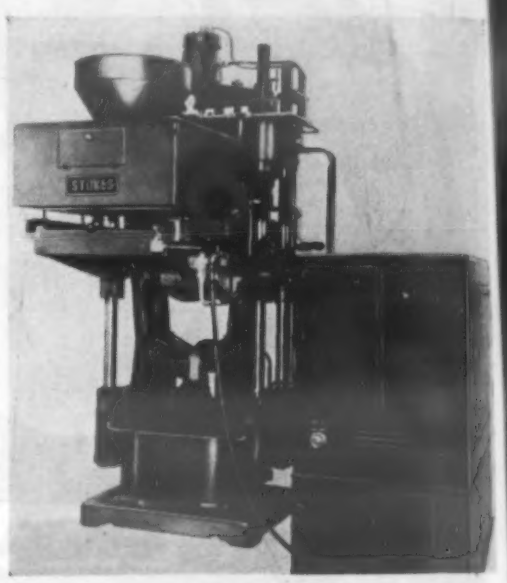
Various combinations are possible, so that a single washer can combine lubrication, lubricant-retention, and sealing against dust, water, etc.

New Materials and Equipment

Automatic Molding Press for Plastic Parts

A new 150-ton fully automatic molding press for high production of a wide assortment of conventional plastic parts has been announced by the *F. J. Stokes Machine Co.*, 5972 Tabor Rd., Philadelphia.

Self-contained, and provided with a positive checking device to control the automatic action of the press through the ejected part, the new press, Model 257, will be useful for producing plastic tube bases, fluorescent sockets, duplex receptacles, stripped closures, flanged bottle tops, knobs, etc., where quantity production is essential. Either preform or powder feed may be used. Positive ejection is accomplished through a separate ejection cylinder.



This plastic molding press is designed for quantity production.

A bar-type control governs all steps in the cycle. The simple, compact power unit operates at relatively low hydraulic pressures, and minimizes leaks, replacement of gaskets, oil seals, and maintenance expense.

Printed Circuits Produced by New Process

Extremely fine spacings, thick conductors, and low cost are reported for the new line of miniature printed circuits and components offered by the *Glass Products Co.*, Dept. 313, 108 N. Dearborn St., Chicago. These elements are produced by a new process called "Micro-screening," which was

(Continued on page 114)

New Materials and Equipment

developed to improve the resolution of silk screening while retaining its chief advantage, namely, the heavy deposits obtainable.

The micro-screened pattern can have any desired size or shape. The lines can be of almost any material, metal or insulator. They can be deposited on any base: metal, glass, plastic, paper, etc., and can be overlaid with other materials.

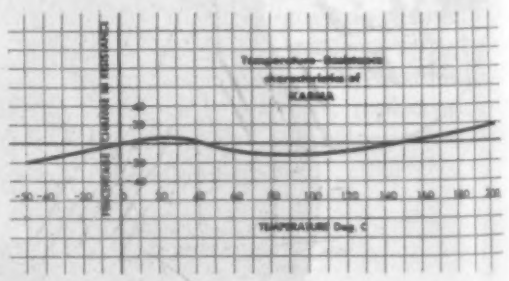
Line widths and spacings of 0.001 in. and accuracies of 0.0002 in. are attainable in production. Conductivity is said to be excellent because the deposit may be made thick. This combination of fine lines and high conductivity is especially favorable for the production of tiny inductances, resistors, potentiometers, phase shifters, and similar circuit elements.

The new method is a high-production process. Pieces are produced at rates comparable with those of conventional silk-screen printing. Since, in addition, comparatively little set-up is required for a production run, the per piece price is reported as low even in moderate quantities.

New Alloy Has Good Electrical Resistance Properties

High electrical resistivity, and the ability to retain resistance values over wide ranges of temperature suit the new alloy developed by the *Driver-Harris Co.,* Harrison, N. J., for high accuracy wire-wound resistors. The new alloy is called Karma.

The alloy's specific resistance at 68 F (20 C) is 800 ohms per circular mil ft.



Temperature-resistance characteristics of the new alloy.

(133 microhms/cm³)—more than 2.7 times that of either Manganin or Advance, the copper-base alloys now widely used for such resistors.

In the making of potentiometers and resistance units used in radio, radar, and other electrical equipment, there is a limiting minimum size specified by many resistance users, due to the lack of mechanical

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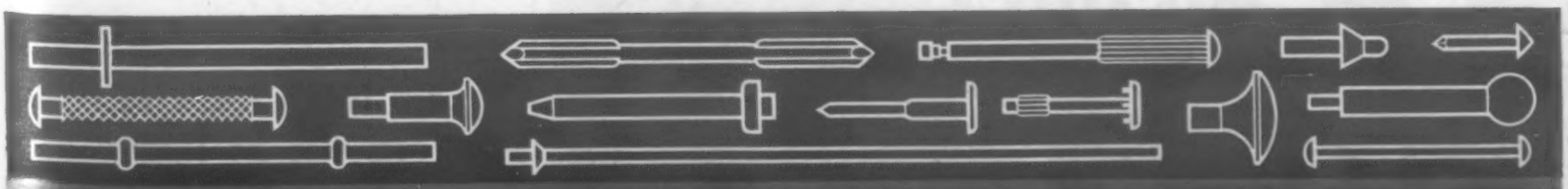

JOHN HASSALL, INC. • 162 CLAY STREET • BROOKLYN 22, N. Y.

New Materials and Equipment

strength. With the use of this alloy, however, it is possible to use a larger diameter of wire for the same resistance per foot due to its higher specific resistance.

The low temperature coefficient of resistance of Karma remains constant over a wider temperature range than that applying to either Manganin or Advance. The "useful range" is eight times that of Manganin and four times that of Advance.

The tensile strength of the new alloy at room temperature is 130,000 to 180,000 psi. This high tensile strength permits faster winding speeds, and helps to increase manufacturing efficiency by enhancing ease of handling.

New Chemical Polish Protects Copper, Brass, Bronze

A chromate-type chemical polish for producing a lustrous, corrosion-resistant surface on copper, brass or bronze surfaces has been introduced by *Allied Research Products, Inc.*, 4004 E. Monument St., Baltimore, Md.

Applicable to sheet, rod, castings or forgings, the polish, called Iridite Metcote, serves as a triple-purpose process: for brightening, tarnish resistance, or paint base. The coating is applied by a short, non-electrolytic dip, operated at slightly elevated temperatures. It is said to offer three advantages over sulfuric or nitric acid polishing solutions in that it is non-fuming and non-critical during operation, and that the work being processed is chemically polished and does not become etched, even from long immersion periods. In addition, production rates may be increased by raising the temperature of the bath.

Work to be processed should first be thoroughly cleaned in standard plating shop solutions. After thorough rinsing, the parts are handled as follows: Iridite Metcote, rinse, optional bleaching dip and rinse, hot rinse and dry.

New Line of A.C. Welders Have Good Arc Stability

Increased welding range and stepless precision current control are announced as the features of a new line of a.c. arc

a Fountain Favorite...

POURS THROUGH SANITARY VALVES OF *Free-Machining* ENDURO STAINLESS STEEL

There's no compromise with quality when it comes to protecting the taste and purity of America's favorite soft drinks. That's why sanitary, easy-to-clean, corrosion-resistant ENDURO Stainless Steel (Type 303) is used for these fountain dispenser valve parts.

From a manufacturing standpoint, there are other reasons, too, for the specification of ENDURO Cold Finished Bars. Close tolerances . . . accuracy of section . . . uniform soundness . . . fine surface finish . . . and UNIFORMLY HIGH MACHINABILITY . . . all combine to keep down unit costs and reject losses.

Whenever you need top machinability plus one or more of the other qualities which only stainless steel can provide, remember to specify Republic ENDURO Stainless Steel Bars—cold finished or hot rolled—and wire. Available for prompt delivery. Write us *today*.

A VALUABLE AID FOR MACHINISTS

It's a handy Speed and Feed Selector to help you in machining stainless steel. Send for one TODAY.. it's FREE.

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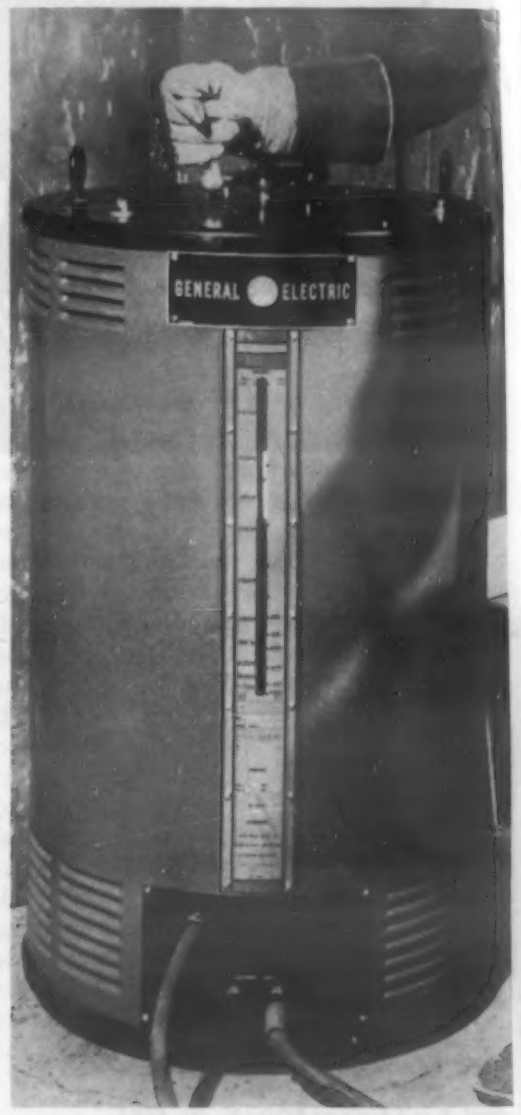
Other Republic Products include Carbon and Alloy Steels—Pipe, Sheets, Strip, Plates, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

New Materials and Equipment

welders by the *General Electric Co.*, Schenectady, N. Y.

The welders are available in 200-, 300-, 400- and 500-amp. models for indoor manual welding, 750- and 1000-amp. models for machine and submerged melt welding, and a special 200-amp. model for light-duty, job-shop welding. The 300-, 400- and 500-amp. models also are offered in weather-resistant enclosures with Idlematic control for both indoor and outdoor operation.

Dual current ranges and increased adjustment overtravel on the new machines provide extra low current range with high maximum short-time output. They are designed with stepless current control, operated by a bearing-mounted current-adjustment crank which enables the operator to make settings throughout the current range.



One of the new line of a.c. welders featuring increased welding range.

The new welders have an open-circuit voltage of 75 v., providing good welding performance through added arc stability. Controls on the weather-resistant models automatically reduce the open circuit voltage on the electrode to about 30 v., but when the arc is struck the advantage of 75-v. open-circuit voltage is retained.

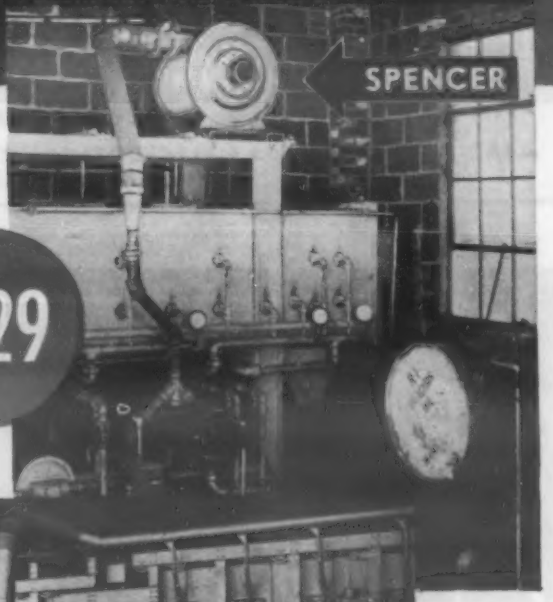
Since 1917

The first Spencer Turbo was installed in 1917. Many of the early machines are still in service. A few of the equipment manufacturers that have used Spencers consistently (see dates) for many years are represented on this page.

1921

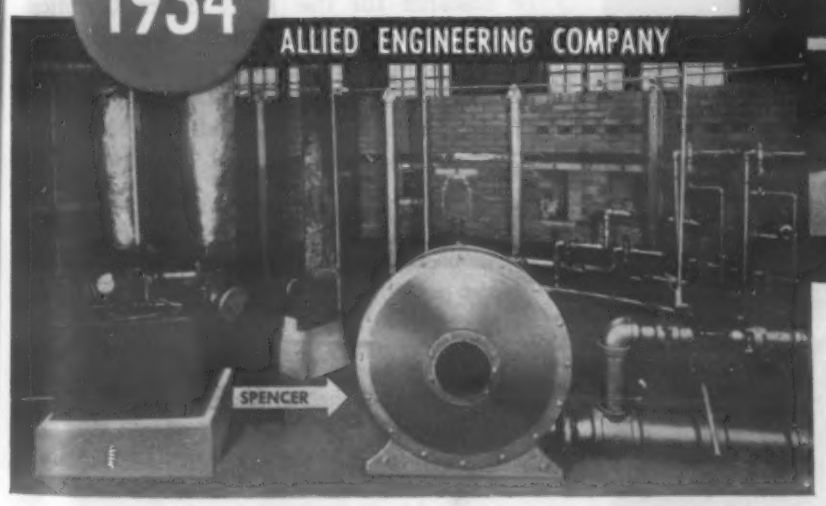
1939

1929



1925

1934



359-F

SPENCER HARTFORD

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONN.

TURBO-COMPRESSORS

News of...

ENGINEERS COMPANIES SOCIETIES

Engineers

Ronald E. Griffiths has been appointed assistant director of research of the American Steel & Wire Co. He succeeds *Willis T. Cramer*, who has been transferred to the post of division metallurgist, for corrosion resisting alloys, in the Company's metallurgical department. Mr. Griffiths' former position as supervisor of the research laboratory has been assumed by *Roland O. Hartman*, a member of the research staff.

The promotion of Dr. *Morris A. Steinberg* to head of the Metallurgical Div. of Horizons, Inc., has just been announced.

Dr. *John C. Mertz* has assumed the position of materials engineer of the Pratt & Whitney Aircraft Div. of the United Aircraft Corp., filling the vacancy left by the death of *Gordon T. Williams*. *Winston H. Sharp* succeeds Dr. Mertz as engineering metallurgist.

Sylvania Electric Products, Inc., has named Dr. *Elmer C. Larsen* as chief engineer of its Tungsten & Chemical Div. Dr. Larsen was formerly assistant director of research for the J. T. Baker Chemical Co. Another appointment was that of *James J. Sutherland* as general manager of Sylvania's Electronics Div. Before his promotion, Mr. Sutherland served as assistant manager of Internal Auditing.

Philip Finale has joined the Loewy Construction Co., Inc., rolling mill division of Hydropress, Inc., as chief engineer. Mr. Finale previously served as rolling mill department engineer of the Mesta Machine Co.

The Atomic Energy Commission has announced the appointment of *Walter L. Maxson* to its Advisory Committee on Raw Materials. Mr. Maxson is vice president of the Oliver Iron Mining Co.

C. W. MacNeill has recently joined the Standard-Thomson Corp. and will direct a new chemical and metallurgical laboratory now being established at 930 S. Ludlow St., Dayton, Ohio. Mr. MacNeill recently was associated with the Fyr-Fyter Co. in the control laboratory.

The resignation of *Melvin C. Harris* as vice president in charge of production of

- TOUGH AND RESILIENT AT SUB-ZERO TEMPERATURES
- DIMENSIONALLY STABLE UNDER TROPICAL CONDITIONS
- PRECISION ANCHORAGE FOR INSERTS
- SUPERIOR ELECTRICAL PROPERTIES
- EASE OF FABRICATION
- COLORABILITY

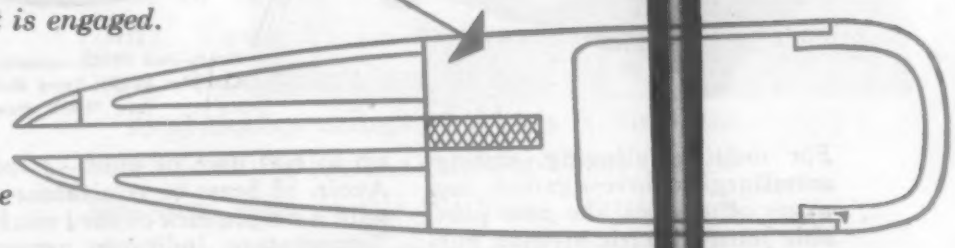
Ethyl Cellulose can Handle it Better

Here's a new twist in screwdrivers—a design that prevents fumbling for that elusive slot in the screw head, and holds the blade securely in the slot once it is engaged.

Only the end sections of the handle are fastened to the metal blade. The center section rides free. This permits the operator to exert continuous pressure against the screw with one hand, while using the other hand to turn.

Designed to be molded with tough ethyl cellulose, this three-piece handle provides firm, precision anchorage of the blade insert, and unrivalled dimensional stability over temperatures ranging from sub-zero to tropical.

Our technical staff invites your inquiries on this and other product improvements.



Suggested design for screwdriver, with three-piece molded housing, by Carl Sundberg, Sundberg & Ferar, Detroit, Mich.

HERCULES POWDER COMPANY *996 Market St., Wilmington 99, Del.*

CP9-5

News of...

ENGINEERS COMPANIES SOCIETIES

the Allegheny Ludlum Steel Corp. has been announced. Pending the election of a successor, *C. B. Pollack,* production manager, will be in charge of production for the company.

The C. M. Kemp Manufacturing Co. has elected *J. Clarence Kimpel* president and chairman of the board, succeeding the late *Wallace W. Kemp. Edward J. Funk, Jr.,* became a vice president, but will continue in his capacity as chief engineer. *Charles E Wilbur,* previously assistant secretary and treasurer, succeeds Mr. Kimpel as secretary and treasurer.

William S. Loose, former director of the laboratory development section of the Magnesium Laboratory, has been appointed sales manager of the Magnesium Div. of the Dow Chemical Co.

The president of the Pennsylvania Salt Manufacturing Co., *Leonard T. Beale,* was re-elected a member of the National Industrial Conference Board for the forthcoming year.

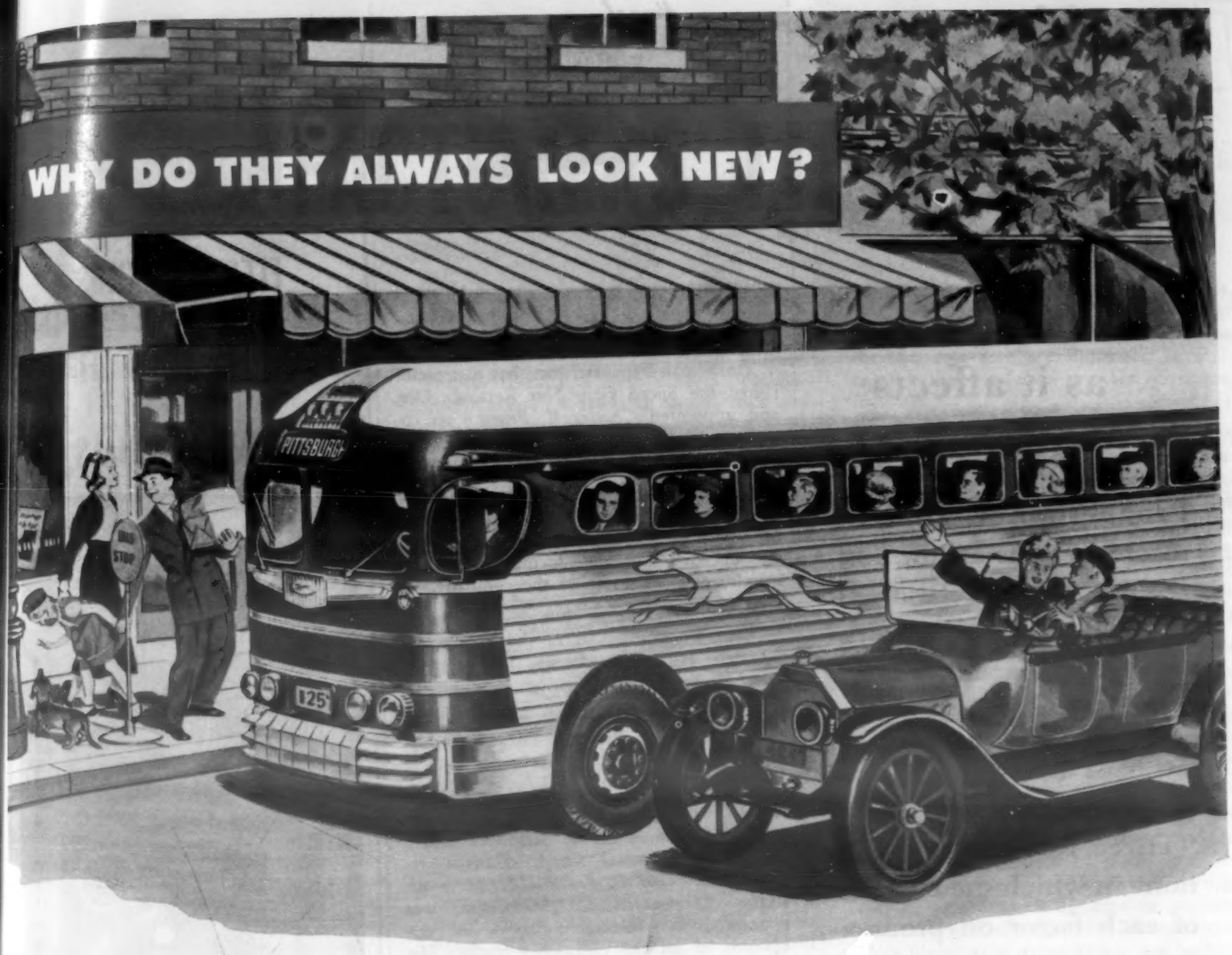
The Rigidized Metals Corp. has named *Roger W. Hofheins* assistant to the vice president-sales, in charge of product development.

Election of *Dawson Spurrier* as president of High Vacuum Processes, Inc., has just been announced. Mr. Spurrier previously served as director and vice president of the company.

James M. Darbaker has been appointed general manager of sales of the Carnegie-Illinois Steel Corp. His former position of Chicago district manager of operations has been assumed by *Stephen H. Jenks,* with headquarters in Pittsburgh. *John H. Vohr* succeeds Mr. Jenks as general superintendent of Carnegie's Gary Steel Works. *Edwin H. Gott,* previously assistant general superintendent of the Gary plant, has been promoted to Mr. Vohr's former position of assistant general superintendent of the South Chicago plant of Carnegie.

Several promotions have taken place recently at the Ferro Enamel Corp. *Ellery Harris* has been named assistant manager and technical director of the Liquid Plastic Div. He formerly was in charge of Vedoc sales in Ohio. Dr. *Frank J. Zvanut* will head Ferro's newly-formed Clay Div., to be located in Nashville, Tenn. And *Earl Skillicorn* succeeds Dr. Zvanut as manager of process and quality control for Ferro's Frit Div.

H. G. Haake, vice president and district manager of Ceco Steel Products Corp.'s Los Angeles office, has been appointed manager in general charge of Ceco operations in all the Pacific Coast states. His headquarters will continue at the Los An-



Many of the new-looking buses you see are 10 or 12 years old.
That's why bus operators like aluminum.
Because ALUMINUM LASTS.

Nature started it . . . by making aluminum light. The bus builders were intrigued; an aluminum bus would save on gas and tires, boost payload. But first, some things had to happen, to make aluminum that would *last.*

Alcoa made those things happen.

We painstakingly created aluminum alloys strong as structural steel. Years of our research produced tough finishes. We invested millions in machinery, to produce the forms of aluminum needed.

Today, for those same reasons, you can expect longer usefulness from many things made of lasting Alcoa Aluminum. Barn roofs. Toys. Window frames. All the things that didn't use to last.

That makes things of Alcoa Aluminum worth looking for. ALUMINUM COMPANY OF AMERICA, 660 Gulf Building, Pittsburgh 19, Penna. Sales offices in principal cities.

ALCOA **FIRST IN ALUMINUM**
THE METAL THAT LASTS

ALCOA ALUMINUM ®

News of...

ENGINEERS COMPANIES SOCIETIES

geles office. *W. F. Norton* was named as assistant district manager of the Los Angeles office.

Tinnerman Products, Inc., has just established the Speed Grip Nut Retainer Div. and appointed *Charles E. Pearson* as coordinator of sales, production and engineering of the new product.

The promotion of *Norman F. Tisdale* to the position of manager of sales of the Molybdenum Corp. of America has been announced. Mr. Tisdale formerly was chief metallurgical engineer of the company.

Irving S. Levinson has joined Ampco Metal, Inc., as manager of the Process Industries. He previously was in charge of the Metallurgical & Testing Div. of the Celanese Corp.

The Harper Electric Furnace Corp. elected *John Loudon* vice president in charge of production and *Edward G. Pierson* vice president in charge of purchasing.

Several changes in the personnel of the Mathieson Chemical Corp. occurred recently. Dr. *Carl F. Prutton,* formerly director of research for Mathieson, was appointed vice president-director of operations of all the company's plants. His headquarters will be in the New York offices. *Arthur T. Bennett,* vice president, was placed in charge of the eight plants acquired from Southern Acid & Sulphur Co., his headquarters to be in Houston, Tex. *R. B. Worthy* and *J. F. Newall* were named vice presidents. Mr. Worthy will be in charge of the plants acquired from the Standard Wholesale Phosphate & Acid Works as well as the Saltville, Va., plant, of which he has been manager. And Mr. Newell will remain at Lake Charles, La., where he has been in charge of the alkali and ammonia plants.

F. S. Cornell has been named assistant manager of the Water Heater Div. of the A. O. Smith Corp. Mr. Cornell previously served as assistant to the president of the company.

The Jessop Steel Co. has promoted *Arthur B. Cooper* from assistant general superintendent to the position of assistant to the vice president in charge of operations.

The Harbison-Walker Refractories Co. announces the death of *H. Schuyler Robertson,* vice president of the company.

The recent death of *Charles H. Wilson,* chairman of the board of the Wilson Mechanical Instrument Co., has been announced. Mr. Wilson was well-known for having perfected the Rockwell Hardness Tester.

(More News on page 132)

MANUFACTURERS' LITERATURE

Materials

IRON AND STEEL

Stainless Steel Sheets and Plates. A 128-page reference and technical handbook for the fabricator, giving complete data on chromium-nickel stainless steel sheets and plates, has been issued by the Eastern Stainless Steel Corp. This attractive book also contains pictorial applications of the numerous fields covered by these products. (1)

Specialty Steels. Typical analysis and applications of a complete line of stainless and heat resisting steels, tool and die steels, and cast-to-shape steels are included in this 20-page booklet, offered by the Jessop Steel Co. (2)

NONFERROUS METALS

Carbide Comparison Chart. This handy, revised comparison chart of cemented carbide grades shows the type of material for which grade is suitable, characteristics and uses, approximate Rockwell hardness on the "A" scale, and lists standard and special equivalent grades of manufacturers under appropriate classifications. Available from the Adamas Carbide Corp. (3)

Nickel-Chromium-Iron Alloys. High temperature design data for Fahralloy nickel-chromium-iron alloys, including graphs, tables and charts, are presented by the Fahralloy Co. in this 12-page bulletin. (4)

Platinum and Other Precious Metals. The Secon Metals Corp. has issued a 4-page folder listing the precious metals—platinum, palladium, rhodium, ruthenium, iridium, osmium, gold and silver—obtainable from them in wire, sheet, foil, ribbon and solders. A precious metals weight calculator that calculates the weight of precious metals in the form of sheet, wire, tubing and circles is also illustrated. (5)

PARTS AND FORMS

High-Alloy Castings. A guide to the selection of the correct Chemalloy high-alloy casting for solving every type of corrosion problem is offered by the Electro-Alloys Div. of the American Brake Shoe Co. in a 6-page, illustrated folder, No. T-171. (6)

Preplated Metals. The American Nickeloid Co. offers a 4-page folder that contains samples of Nickeloid metals finished in chromium, copper, nickel and brass, available on zinc, steel, copper, brass and aluminum bases in bright and satin finishes, striped corrugated and crimped designs. Specifications of available sheets, coils and flat stripes are included. (7)

Precision Investment Castings. An interesting article on precision investment castings is presented by the Arwood Precision Casting Corp. in this 16-page, illustrated bulletin, including a table of alloys found by Arwood to be most adaptable to its process. (8)

Working Pressures for Tubes. Technical data card No. 113, consisting of a useful table listing the maximum allowable working pressures in psi. for seamless and electric resistance welded carbon steel tubes or nipples for different diameters and gages of tubes conforming to certain ASME specifications, is available from the Babcock & Wilcox Tube Co. (9)

Porous Bronze Bearings. This 16-page, illustrated bulletin lists hundreds of sizes and types of "Compo" oil-retaining porous bronze bearings carried in stock, and gives bearing formulae, tolerances, loads and specifications. Available from the Bound Brook Oil-Less Bearing Co. (10)

Stainless Steel Castings. The first issue of *Newscast,* a new publication which will be of interest to those who design, specify, use or purchase stainless steel valves, fittings and engineered castings, is now available from the Cooper Alloy Foundry Co. (11)

Corrosion Resistant Valves, Piping Materials, Etc. The Crane Co. has issued a new 32-page bulletin, No. 320, containing complete data on its line of valves, fabricated piping, pipe coils, and fittings that meet a wide range of corrosive conditions. (12)

Metallic Friction Material. Gempco, a compressed metallic friction material that offers stable friction coefficient at all operating temperatures from cold to hot, available in grades for either dry or oil applications, is discussed in this 12-page, illustrated bulletin, released by the General Metals Powder Co. (13)

Steel Tubes. Helpful tables of tolerances, range of sizes, wall thicknesses, analyses and properties of a variety of Globe seamless and electric welded stainless steel tubes, as well as photos of the facilities of the Globe Steel Tubes Co. for producing these tubes, are included in this 8-page, illustrated bulletin, No. 103-D. (14)

Precision Castings. Various small parts using precision castings of brass, bronze, beryllium, copper, carbon steels, stainless steels, tool steels, and the nonmachinable alloys used for high temperatures and extreme abrasion resistance are illustrated in a 4-page bulletin released by Gray-Syracuse, Inc. (15)

Wires for Spring, Wire Forms, Etc. A detailed table containing nominal composition, tensile strength, weight and electrical conductivity of various types of wires for springs, wire forms, wire rope, specialty parts, etc., appears on one side of this chart, and a wire gage and footage table on the other. Available from Little Falls Alloys, Inc. (16)

Aluminum and Magnesium Die Castings. The facilities of Litemetal DiCast, Inc. for producing aluminum and magnesium lightweight pressure die castings are profusely illustrated, and complete data on the selection of the best light metal alloy to use are included in this 12-page bulletin. (17)

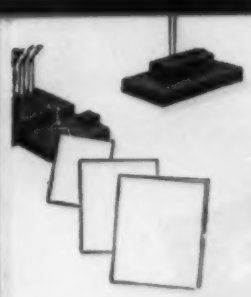
Machining Iron Castings. This 20-page, illustrated bulletin, No. 29, presents in great detail an accumulation of machining data on how to machine Meehanite castings, divided according to the type of machine tool on which the operation is performed. Very useful as a set-up guide, this bulletin is available from the Meehanite Metal Corp. (18)

Centrifugally Cast Pipe and Tubes. Detailed specifications of a variety of stainless, corrosion resisting and heat resisting Misco Centricast pipe and tubes, supplied with plain or threaded ends, or with several standard types of flanged connections, are included in this 12-page, illustrated bulletin, No. C-4, issued by the Michigan Steel Casting Co. (19)

Castings. The facilities of the Monarch Aluminum Manufacturing Co. for producing aluminum permanent mold castings, aluminum alloy die castings, and zinc die castings are profusely illustrated in this 16-page bulletin, No. A-100. Tables of alloy properties are included. (20)

Pressed Powder Parts. The New Jersey Zinc Co. has just released the first issue of a new house organ, entitled *Metal Powder Press,* which will be published quarterly. Each issue will contain interesting case histories on nonferrous pressed powder parts. (21)

Sheet Metal Parts and Assemblies. The large facilities of the Stolper Steel Products Corp. for fabricating a wide range of sheet metal parts and assemblies are profusely illustrated and described in an attractive, 24-page booklet. Various products made to cus-



MANUFACTURERS' LITERATURE

tomers' specifications are also pictured. (22)

Metal Spinning. The facilities of the Roland Teiner Co., Inc. for sheet metal working and spinning of all metals, including stainless steel, are discussed in this 4-page, illustrated bulletin. (23)

Special Purpose Wire and Flat Steels. This attractive, 12-page bulletin pictorially presents a large and varied assortment of products containing either high quality wire of small diameter sizes in round, flat, square and special shapes or low or high carbon flat spring steel. Available from the Worcester Wire Works Div., National-Standard Co. (24)

PLASTICS

Polyvinyl Chloride Materials. The B. F. Goodrich Chemical Co. has published a 4-page chart that contains a summary of the Geon resins, plastics and latices available, suggested compounding methods and ingredients that can be used, processing suggestions, and finished products possible. (25)

Cellulose Esters. Specifications and characteristics of the standard types of Eastman Cellulose Acetate, Cellulose Triacetate and Cellulose Acetate Butyrate, together with data on their uses with solvents, plasticizers and resins, are included in this 38-page, illustrated handbook, eighth edition, offered by the Tennessee Eastman Corp. (26)

NONMETALLICS

Precision Cut Felt Parts. Complete data on precision cut felt parts, including a pictorial section on the manufacture, cutting and typical uses of felt parts, and four samples of SAE felts produced by the Felters Co., are presented in this 44-page manual. (27)

Methods and Equipment

HEAT TREATING

Continuous Reciprocating Furnaces. Both the full muffle controlled atmosphere type and open hearth type of continuous reciprocating furnaces for clean hardening, normalizing, carburizing and case hardening by the patented Ni-Carb process, and for other types of general and atmosphere work are described and illustrated in this 4-page bulletin, No. 815, issued by the American Gas Furnace Co. (28)

Super Refractories for Heat Treatment Furnaces. A concise description of a variety of super refractories for heat treatment furnaces, their physical characteristics, how they are applied to specific types of furnaces, operational advantages, installation data, and numerous tables comprise this 40-page, illustrated bulletin offered by the Refractories Div. of the Carborundum Co. (29)

Heat Treating Unit. Model CH, a gas-fired heat treating unit equipped for heat treating all types of water or oil hardening steel, for heating, quenching and drawing, and for stress relieving, normalizing and annealing, is described and illustrated in this 4-page bulletin, No. D-150, issued by the DoAll Co. (30)

Quenching Furnace. A detailed diagram of the Type 401 Marquenching Furnace for hot quenching operations, which can be heated either by immersed electrodes, resistance calrod units or under-fired gas burners, is featured in this 10-page bulletin, released by the A. F. Holden Co. Specifications are included. (31)

Induction Heating Equipment. Greater speed, uniformity and economy in hardening, annealing, brazing, soldering and melting operations through the use of various high frequency induction heating units produced by the Lepel High Frequency Laboratories, Inc. is explained in this 36-page, illustrated catalog. Specifications are included. (32)

Rotary Hearth Heating Furnaces. The many advantageous features of various rotary hearth heating furnaces designed and built by the Salem Engineering Co. to provide continuous flow in hot work preparation for ferrous and nonferrous metals are listed in this 8-page, illustrated bulletin. (33)

Industrial Furnaces. A variety of industrial furnaces and controlled atmosphere generating assemblies for bright annealing, brazing, hardening, sintering and soldering operations are described and illustrated in a 4-page bulletin issued by Sargeant & Wilbur, Inc. (34)

WELDING AND JOINING

Hardfacing. An 8-page, illustrated reprint that reviews the advantages of hardfacing and offers an analysis of the problems leading to the correct selection of the proper hardfacing rods has been issued by the Air Reduction Sales Co. (35)

Stainless Steel Fasteners. All types and sizes of stainless steel machine, self-tapping, socket, set and wood screws, nuts, bolts, washers, rivets and pins are described and illustrated in bulletin No. 49E, offered by the Allmetal Screw Products Co. (36)

Industrial Fasteners. Time and money-saving case histories that show how Bostitch machines for stapling and wire stitching render better and faster work are reviewed by Bostitch in its 16-page, illustrated bulletin, No. PTG 223. (37)

Welding Positioners. A profusely illustrated circular of Cullen-Friestedt Co. examines the factors involved in handling weldments of various sizes and shapes, and describes the use of positioners to provide economy, convenience and safety. (38)

Elastic Stop Nuts. A complete line of Esna elastic stop nuts, their specifications, applications, materials and finishes, is presented in 33 illustrated data sheets, offered by the Elastic Stop Nut Corp. of America. (39)

Air Operated Press. The new air operated Han-D-Press, especially designed for production assembly, staking, pressing, marking, riveting and other light operations is described and illustrated in bulletin No. 251, offered by the Hannifin Corp. Specifications of this press, available in ½-ton and 1-ton sizes, are included. (40)

Arc Welding Equipment. This 20-page, pocket-size booklet, No. W-74, describes and illustrates a complete line of a.c. and d.c. arc welders, welding generators, welding positioners, arc torches, production welding control systems, welding electrodes, self-powered arc welders, and arc welding accessories, produced by the Harnischfeger Corp. (41)

Special Nails, Rivets, Screws. John Hassall, Inc. offers a bulletin describing its complete line of special nails, rivets and screws, made in diameters from 1/32 to ⅜ in., lengths up to 7 in., in a variety of metals and finishes. (42)

Arc Welding. Interesting case histories and ideas on how to use arc welding most effectively in cutting factory operating costs and production costs are presented in an 8-page, rotogravure news sheet, *It's Welding Time*, Vol. 9, No. 2, published by the Lincoln Electric Co. (43)

Stud Welding Gun. Twenty-four typical applications of the Nelson stud welding gun, which eliminates drilling, tapping and hand welding, are illustrated and described in this 8-page bulletin, issued by the Nelson Stud Welding Div. of the Morton Gregory Corp. (44)

Welding Equipment. This 44-page, illustrated catalog, No. 149, contains brief descriptions and prices of a complete line of welding equipment, from welding and cutting assemblies to helmets, goggles, gages, hose clamps, etc. Available from the Smith Welding Equipment Corp. (45)

Somewhere in your manufacturing operations there may be a place where a specially-designed fastening would prove both practical and economical. In appearance, it might resemble some of the standard fastenings you are now using. Or, depending upon the job it has to do, it could be decidedly different in size or shape, or even in the composition of the steel.

Supplying special fastenings to meet the needs of industry is part of the day's work at Bethlehem's Lebanon, Pa., plant. Fastenings with hook-heads, curved- or T-heads, square shanks, forged-on washers —Lebanon Plant makes them all, plus hundreds more. And in addition, we also turn out a complete range of standard items—machine and carriage bolts, nuts, rivets and spikes.

If you have a fastenings problem, or suspect that the use of a "special" in place of standard fastenings would prove more satisfactory and economical, put it up to our staff of engineers. We'll be pleased to hear from you at any time.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

Bethlehem supplies every type of Fastening

News of...

ENGINEERS
COMPANIES
SOCIETIES

Companies

The *Linde Air Products Co.*, a unit of the *Union Carbide & Carbon Corp.*, has begun production of Prest-O-Lite acetylene at its new plant, located at 2520 S. Second St., P. O. Box 805, Albuquerque, New Mex. A warehouse for the distribution of Union Carbide is also on the plant premises.

Completion of a new office building adjoining the producing unit of the Ansonia Branch of the *American Brass Co.* has been announced. Located at 75 Liberty St., Ansonia, Conn., the new branch will handle all the functions of sales and service formerly carried on at Company headquarters in Waterbury.

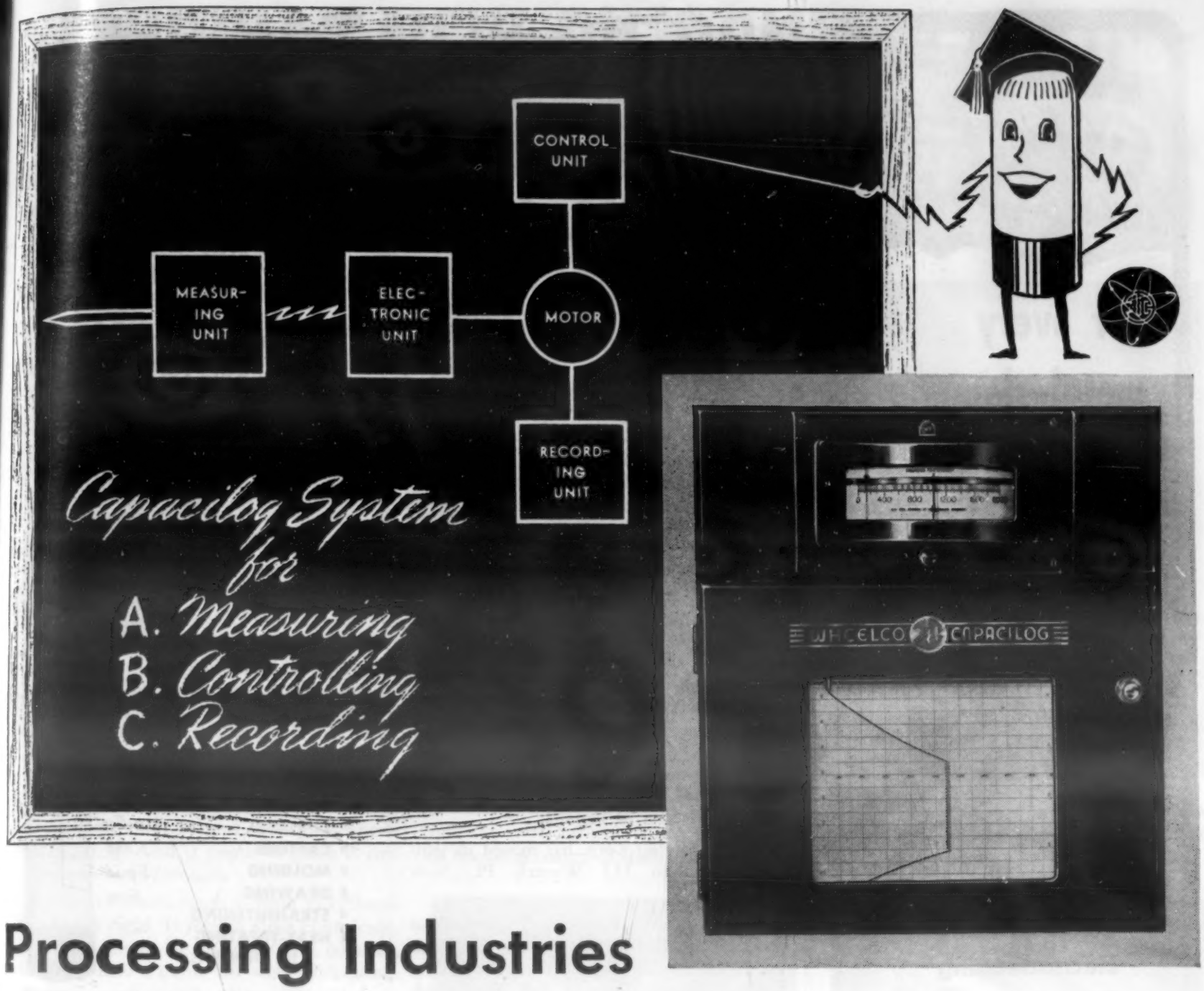
The assets and business of the *Bryant Heater Co.* have been purchased from *Dresser Industries* by *Affiliated Gas Equipment, Inc.* The manufacture and sale of all former Bryant Heater products, using the same trade names, will be continued with no change in personnel. All correspondence relative to industrial gas combustion equipment should be addressed to the Bryant Industrial Div., Affiliated Gas Equipment, Inc., 1020 London Rd., Cleveland 10, Ohio. L. R. Foote will continue as Eastern Industrial Specialist, with offices at 122 E. 42nd St., New York 17.

The Pacific Coast Div. of *Revere Copper & Brass, Inc.*, was formally opened at 6500 E. Slauson Ave., Los Angeles, Calif., last month. The plant, which will produce copper and copper alloy rods and tubes, is headed by Wallace H. Hitchcock as division manager, and Charles J. Paumier is works manager.

Changes in the organization of the *Owens-Corning Fiberglas Corp.* resulted in the establishment of a *General Products Div.* at the firm's main offices in Toledo, and a *Textile Products Div.* at 16 E. 56th St., New York 22. W. P. Zimmerman, executive vice president, was named general manager of the General Products Div., and J. H. Thomas, vice president, is general manager of the Textile Products Div.

The business and products of the *Universal Boring Machine Co.*, Hudson., Mass., have been acquired by the *Bullard Co.* Manufacture of the Universal Horizontal Boring Mills, to be known as the Bullard-Universal Boring Machines, and the Precision Machine Aligning Level will be continued at the Bullard plant, Bridgeport, Conn.

Effective immediately, the *Detrex Corp.*, Detroit 32, Mich., is extending the use of their registered trade name, Detrex, for identification of alkali cleaning compounds, strippers, emulsion cleaners, and wet spray booth materials. Also, the registered trade name "Triad" is now being reserved exclusively for use in identifying the Corporation's chlorinated hydrocarbon solvents



Processing Industries *are sold* on the CAPACILOG . . . . . *because*. . . .

Engineers like the functional simplicity of the Capacilog Recorder as demonstrated on the "blackboard" chart. No converters or relays are required in the instrument. There is no mechanical or electrical disturbance in the measuring system. The control system operates without physical contact with the measuring system, and is directly synchronized with the recording system. The strip chart of the recorder provides immediate pen response accurate to one tenth of one percent of the instrument range.

You may now combine both accuracy of record with instrument serviceability on your process variable by installing one of these simple and economical Strip Chart Recorders. Whether your application is in the Metal, Chemical, Ceramic, Plastic or Laboratory Classification, there is a model for your purpose.

WHEELCO INSTRUMENTS COMPANY
861 W. HARRISON ST., CHICAGO 7, ILL.

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☐ C2—Strip Chart Recorder
☐ Z6500—Condensed Catalog

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City..... *State*.....

WHEELCO *Electronic* CONTROLS

RECORDERS • COMBUSTION SAFEGUARDS • CONTROLLERS

News of...

ENGINEERS COMPANIES SOCIETIES

for vapor degreasing and oil extraction.

Williams & Co., Inc., has moved into its new warehouse at 3231 Fredonia Ave., Cincinnati.

David V. Uihlein has acquired the *Banner Manufacturing Co.*, 4951 N. 29th St., Milwaukee 9, and will act in the capacity of executive director. Arthur Kranitz remains in charge of production.

The *Reynolds Metals Co.*, Louisville, Ky., has purchased a Government-owned aluminum extrusion plant at Grand Rapids, Mich. The plant is designed for the production of high strength aluminum rod, bar, shapes and tubing, and will be ready to start production this month.

Announcement has been made of the formation of a new firm, the *Vacuum Casting Corp.*, located at 401 E. Erie Ave., Philadelphia 34. The purpose of this organization is to develop and exploit new processes of refining and casting of metals. Officers of the company consist of F. O. Hess, president; E. W. Mason, secretary; R. L. Wood, treasurer; and Davidlee Von Ludwig, director of research.

Cerium Metals Corp. has moved its general offices to 153 Waverly Pl., New York 14.

The manufacturing and distribution rights of TROXIDE Compounds have been purchased by *MacDermid, Inc.*, Waterbury, Conn., from the *Waverly Petroleum Products Co.*, Philadelphia. Also, a new department has been formed by MacDermid to develop and promote TROXIDE and allied acid salt compounds for metal finishing, to be headed by Thomas F. O'Brien, formerly in charge of the Industrial Chemical Div. of Waverly.

A new research laboratory has been opened in the Juan Franco area of Panama City, Panama, by the *Eastman Kodak Co.*, as well as a jungle test station on Barro Colorado Island in Gatun Lake, part of the Panama Canal. These new facilities were designed for the study of photographic materials under tropical conditions.

The *Minnesota Mining & Manufacturing Co.* has started the production of adhesives and coatings at the former Plancor plant No. 80, located at Bristol, Pa. Robert N. Wolfe has been named manager of the plant.

The Tube Expander business of *Richard Dudgeon, Inc.*, New York City, has been purchased by *Thomas C. Wilson, Inc.*, Long Island City, N. Y. Wilson will combine the manufacture of Wilson Tube Cleaners and Wilson-Dudgeon Tube Expanders at its Long Island City plant, located at 21-11 44th Ave. Richard Dudgeon, Inc., will now devote its entire efforts to the production of hydraulic machinery.

A new plant and office building has been

UNUSUAL NEW DU PONT PLASTIC USED IN VARIETY OF NEW PRODUCTS

Versatile polythene promises to play big part in future of American industry

Have you seen the new ice tray that releases its cubes at a twist of the wrist? Or have you seen those new *bottles* that spray out their contents when squeezed . . . and *won't break* when dropped?

These and hundreds of other fascinating new products are being made of Du Pont polythene . . . one of the most remarkable materials of modern chemistry.

Polythene molding powders are made in a wide range of colors by the Plastics Department of the Du Pont Company. Extruders, molders, and other processors convert the material into molded products, film, tubing, tape, filaments, etc.

In thin sections, polythene is tough and flexible. A new baby bottle made of polythene is soft, pliable, and strong. It needs no sterilizing. And it costs so little it *can be thrown away after use.*

In thick sections, such as pipe, polythene is relatively rigid. It resists most chemicals. As tubing it can be bent around corners, and rolled like a cable for easier handling.

During the war, polythene first came into use as an insulation material for high-frequency wire and coaxial cable. Since then it has found wide use in the electrical field. Current uses include jacketing for power cables and insulation for the coil in a new watt-hour meter.

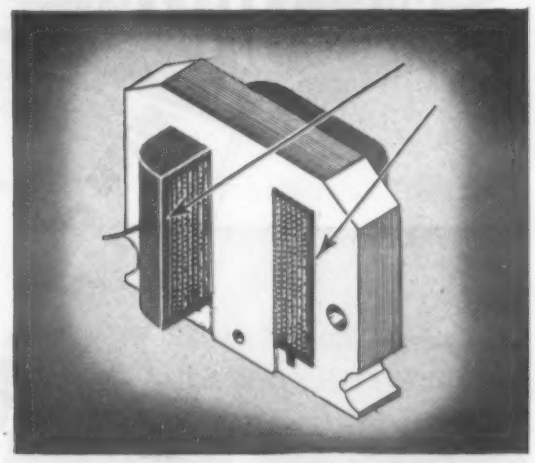
Polythene's unusual combination of properties is especially useful in the packaging field. It can be heat-sealed. It keeps out water, dust, and bacteria. And it stays tough and strong at low temperatures . . . is tasteless, odorless, and nontoxic. Items now packaged in polythene include foods, cosmetics, corrosive chemicals, and metal parts.

Manufacturers are making more and more new products of all types with DuPont polythene. For polythene offers so many advantages at low cost—including ease of molding, extrusion and machining.

The demand for polythene still exceeds the supply, but continuing increases in production are being pushed to catch up with demand. More information on uses and specific properties of polythene can be obtained from E. I. du Pont de Nemours & Co. (Inc.), Plastics Department, Empire State Building, 350 Fifth Avenue, New York 1, N. Y.; 7 South Dearborn Street, Chicago 3, Illinois; 845 East 60th Street, Los Angeles 1, California.

APRON, pitcher, tumblers, ice-cube tray, ice tub, bowls, sugar bowl, cream pitcher and tablecloth protector are all made of Du Pont polythene. Names of manufacturers of items shown above available on request.

SQUEEZABLE BOTTLES, blow molded from polythene, package products ranging from cosmetics to corrosive chemicals. (Deodorant bottle molded by Plax Corp., Hartford, Conn., for Jules Montenier, Inc., Chicago.)



POTENTIAL COIL for new watt-hour meter is insulated with Du Pont polythene for greater strength, reliability and secure positioning. (Watt-hour meter manufactured by General Electric Co., Schenectady, N. Y.)

DISPOSABLE BABY BOTTLE made from Du Pont polythene extruded as continuous, flat, sterile tubing; heat-sealed to form 4- or 8-oz. sections. (Made by Shellmar Products Corp., Mt. Vernon, Ohio.)

News of...

ENGINEERS COMPANIES SOCIETIES

erected by the *Ceco Steel Products Corp.* at 401 Tunnel Ave., San Francisco. Ceco's San Francisco organization is now located at this new address.

Societies

The *American Society of Tool Engineers* elected new officers for the current year at their recent annual meeting. They include Robert B. Douglas, president of Godscroft Industries, Ltd., who succeeds I. P. Holland as president. Herbert L. Tigges, vice president of Baker Brothers, Inc., was named first vice president. J. J. Demuth, general superintendent of the Sligo Iron Stove Co., is second vice president. Halsey F. Owen, professor of industrial engineering at Purdue University, was elected third vice president. Reelected as secretary and treasurer, respectively, were William B. McClellan, sales engineer for the Gairing Tool Co., and G. A. Goodwin, chief process engineer of the Master Electric Co.

The Executive Committee of the *Magnesium Association* took action to employ R. B. Brown as the new executive vice president and general manager of the Association.

The program committee of the *Society of the Plastics Industry* has planned to highlight the subject of economics throughout their 2-day annual meeting, to be held May 26 and May 27 in Chicago. C. L. Cruver, Jr., of the Cruver Manufacturing Co., heads the program committee.

The *College of Engineering* at the *University of Notre Dame* has been accepted for membership in the *Engineering Research Council* of the *American Society for Engineering,* a national organization of engineering schools and educators with chapters in all states of the nation.

Dr. Harry K. Ihrig, vice president and director of laboratories of the Globe Steel Tubes Co., has received a citation for distinguished service in engineering from the *College of Engineering* of the *University of Wisconsin.*

New officers of the *Cutting Tool Manufacturers' Assn.* include the following: president—Emil Gairing, president of Gairing Tool Co.; vice president—Norman Lawton, works manager of the Star Cutter Co.; treasurer—R. S. Spencer, president of the Detroit Boring Bar Co.; and continuing as executive secretary—Harry J. Merrick.

The first of a series of technical bulletins of definite significance to gray iron producers has been issued by the *Gray Iron Founders' Society.* No definite schedule for the release of future bulletins has been established.

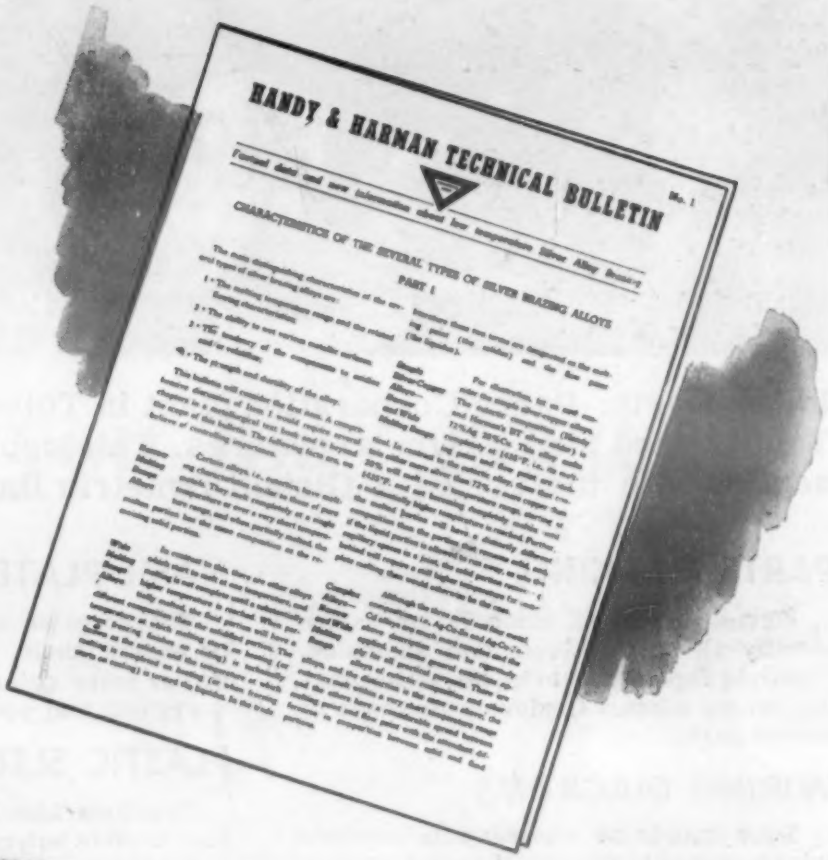
Strictly Technical

Investigation into every phase of low-temperature silver alloy brazing is being carried on continually in our Research Laboratories.

Believing that many engineers are interested in the valuable factual data and new findings being uncovered, we are making the data available in the form of Bulletins, two of which, covering characteristics of various types of silver brazing alloys, have already been published. Included among the subjects of future bulletins are—

- **Strength of Joints—Tensile, Shear, Impact and Fatigue**
- **Joint Design from Standpoint of Stress Distribution**
- **Expansion and Contraction of Parts in Brazing**
- **Diffusion and Alloying with Joint Components**
- **Fluxes—Functions and Special Compositions**
- **Brazing Cast Iron**

If you would like to receive free copies of these strictly *Technical Bulletins* as they are published, fill in and mail the COUPON and we'll send you those already issued and put your name on the mailing list for future copies.


HANDY & HARMAN TECHNICAL BULLETIN

No. 1

Factual data and new information about low temperature Silver Alloy Brazing

CHARACTERISTICS OF THE SEVERAL TYPES OF SILVER BRAZING ALLOYS

PART I.

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Meetings and Expositions

INSTRUMENT SOCIETY OF AMERICA, spring meeting. Toronto. May 12-13, 1949.

INDUSTRIAL FURNACE MANUFACTURERS ASSOCIATION, annual meeting. Virginia Beach, Va. May 16-18, 1949.

OIL HEAT INSTITUTE OF AMERICA, annual convention. Boston, Mass. May 16-20, 1949.

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, spring meeting. Detroit, Mich. May 19-21, 1949.

SOCIETY OF APPLIED SPECTROSCOPY, one-day symposium. Brooklyn, N. Y. May 21, 1949.

SOCIETY OF THE PLASTICS INDUSTRY, INC., national meeting. Chicago, Ill. May 26-27, 1949.

METAL TREATING INSTITUTE, spring meeting. Quebec, Canada. May 30-June 1, 1949.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting. French Lick Springs, Ind. June 5-10, 1949.

STEEL FOUNDERS' SOCIETY OF AMERICA, industrial relations meeting. Chicago, Ill. June 9-10, 1949.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Applied Mechanics Div. conference. Ann Arbor, Mich. June 13-15, 1949.

MALLEABLE FOUNDERS' SOCIETY, annual meeting. Hot Springs, Va. June 16-17, 1949.

NATIONAL ASSOCIATION OF PURCHASING AGENTS, annual convention. Chicago, Ill. June 20-22, 1949.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, summer general meeting. Swampscott, Mass. June 20-24, 1949.

AMERICAN ELECTROPLATERS' SOCIETY, annual convention. Milwaukee, Wis. June 27-30, 1949.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, semi-annual meeting. San Francisco, Calif. June 27-30, 1949.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting. Atlantic City, N. J. June 27-July 1, 1949.

INSTITUTE OF THE AERONAUTICAL SCIENCES, summer meeting. Los Angeles, Calif. July 21-22, 1949.

PRESSED METAL INSTITUTE, national conference. Cleveland, Ohio. July 21-22, 1949.

SOCIETY OF AUTOMOTIVE ENGINEERS, West Coast meeting. Portland, Ore. August 15-17, 1949.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, Instruments & Regulators Div. conference. St. Louis, Mo. Sept. 12-16, 1949.

INSTRUMENT SOCIETY OF AMERICA, annual meeting. St. Louis, Mo. Sept. 12-16, 1949.

BOOK REVIEWS

Handbook of Plastics

HANDBOOK OF PLASTICS—SECOND EDITION. *By H. R. Simonds, A. J. Weith & M. H. Bigelow. Published by D. Van Nostrand Co., Inc., New York, 1949. Fabrikoid, 6 x 9½ in., 1463 pages. Price $25.00.* The first edition of this Handbook has been largely re-written in order to incorporate the new materials and new processes that have appeared since its publication.

Plastics are covered from raw materials to finished products, including details of the manufacturing methods, machinery and processes for the plastics themselves, as well as the articles into which they are fabricated. Physical, thermal, mechanical, chemical, physico-chemical and electrical properties of the commercial plastic materials in their use for determining their fields of application and methods of processing, fabricating and finishing are included.

The chapter titles are: Survey of the Industry; Properties of Plastics; Commercial Materials; Primary Ingredients; Characteristics of the Various Plastics; Textile Fibers; Rubbers and Elastomers; Natural Resins; Films and Sheetings; Laminates and Plywoods; Coatings; Adhesives; Manufacturing Processes; Plant Equipment; Processing and Fabricating; Finishing Operations; Molds; The Chemistry of Plastics; Analytical Methods; Applications; Designing Molded Parts; Operating Practice; Choice of Plastic; Cost Accounting in the Industry; Patents in Plastics; and World Plastics.

The listing of trade marks and trade names, glossary, bibliography and useful tables are especially helpful. The very fine index adds greatly to the usefulness of this excellent handbook.

Engineering with Rubber

ENGINEERING WITH RUBBER. *Edited by Walter E. Burton. Published by McGraw-Hill Book Co., Inc., New York, 1949. Cloth, 6¼ x 9¼ in., 486 pages. Price $6.50.* Describes engineering, design and maintenance principles to be considered when using rubber in industry—emphasis is placed on the applications of these principles. Basic information on physical and chemical properties of various rubber compounds, structural details and typical dimensions of industrial rubber products is provided.

Special attention is paid to the design and construction of rubber parts from American-made rubber (formerly classed as synthetic rubber), crude rubber and rubber-like materials. Adhesive, elastic, tensile, electrical and chemical properties are covered. Information on some non-rubber materials such as plasticized polyvinyl chloride is also included.

Among the chapters are those on: Types and properties of rubber; rubber adhesives, belting, mountings, hose, linings, printing materials, thread and tape; latex products; extruded, hard, lathe-cut, molded and sponge rubber; rubber in hydraulic equipment; packing and sheet rubber; and rubber-covered rolls.

Other New Books

DESIGN OF INDUSTRIAL EXHAUST SYSTEMS—SECOND EDITION. *By John L. Alden. Published by the Industrial Press, New York, 1948. Fabrikoid, 5¾ x 8¾ in., 252 pages. Price $3.50.* Information is given on how to design and build or how to buy adequate and low-cost exhaust systems. Recent advances are covered in this edition.

NEW ADVANCES IN PRINTED CIRCUITS (NATIONAL BUREAU OF STANDARDS MISC. PUB. M 192). *Available from Supt. of Documents, U. S. Government Printing Office, Washington 25, D. C. 73 pages. Price 40c.* Twenty-two papers presented at a symposium held by the Aeronautical Board's Aircraft Radio and Electronics Committee under the technical supervision of the National Bureau of Standards are included in this pamphlet.

THE MEASUREMENT OF STRESS AND STRAIN IN SOLIDS. *Published by Institute of Physics, London, S. W. 1, England, 1948. Cloth, 6¼ x 9¾ in., 114 pages. Price 17s. 6d. ($4.00 in U.S.A.).* Contains 12 papers presented at a two-day conference held at the University of Manchester in July 1946 and summaries of the discussions on them.

CORRECTION

The correct price for "Mathematics at Work," by H. L. Horton, reviewed in our March 1949 issue, is $6.00.

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The Last WORD

by **FRED P. PETERS,** *Editorial Director*

Man's Inhumanity to Man

Sometimes it's about as easy to reconcile design, materials and production factors in a plant or product as it is to get a Phi Beta Kappa man to wear a double-breasted suit. For this reason the designer, materials engineer or production man often has a fine disregard for the abilities and wishes of the other members of the team.

To the average engineer, production executives are well-meaning men that are as in-the-dark about technical matters as a sheet steel salesman is about delivery dates. Conversely, too many production men have a completely wrong understanding of the meaning of the B.S. following the technical man's name. One of the best commentaries on *design* engineers written doubtless by some (anonymous) production man is that now-classic verse "The Successful Designer." In our opinion this ought to be regularly printed and reprinted in every technical journal as a reminder of the easy pitfalls along the single tract:

The Successful Designer

The designer bent across his board
Wonderful things in his head were stored
And he mumbled while rubbing his throbbing bean;
How can I make this tough to machine?
If this part here were only straight
I'm sure the thing would work first rate.
But 'twould be so easy to turn and bore
It would never make the machinists sore.
I'd better put in a right angle there
Then watch those shop men tear their hair.
And I'll put the holes that hold the cap
Way down in here where they're hard to tap.
Now this piece won't work I'll bet a buck
For it can't be held in a shoe or chuck.
It can't be drilled—it can't be ground
In fact, the design is exceedingly sound.
He looked again and cried "At last!
Success is mine—it can't even be cast."

A Grain of Salt

Consumers' Research *Bulletin,* respected organ of the generally battered and bleeding consumer, did a recent piece on stainless steel cooking utensils that will afford him little real nourishment, even when taken with a grain of salt.

The article reported the results of accelerated corrosion tests on several stainless pots in a boiling mixture of tartaric acid, acetic acid and salt (try *that* on your dinner guests some night), which extracted varying amounts of chromium (sometimes with nickel) from the metal. These results are compounded with figures on the toxicity of chromium plus the allergic effects of nickel, and the result is an alleged "hazard" for all those who eat food cooked in a stainless steel utensil, especially one "which no longer retains its smooth interior finish or that shows signs of pitting or corrosion."

This could be just another unhappy instance of foolishly using synthetically concocted over-simplified corrosion conditions as a gage of performance in different, complex and varying environments, except that the report may scare the wits out of thousands of consumers who have been cooking their food in stainless pots for years and who should therefore be dead of chromium poisoning or suffering from "nickel itch" by now.

Our guess would be that service tests on the utensils, using foods themselves rather than impossibly strong synthetic mixtures, would show that stainless steel utensils are no more hazardous than is, for example, aluminum, which for years had to contend with the same kind of semi-scientific observations. For one thing, rates of corrosion are not directly extrapolable. For another, the character of corrosion products change with the concentration of corrosives. And for still another, much has yet to be learned about the toxicity of these corrosion products.

The best we can do is offer this grain of salt until Consumers' Research or somebody else makes some real tests.

Springfield in the Spring, Tra-La!

A.I.M.E. put on a New England Regional Conference at Springfield, Mass. which was a little gem and not at all the long-haired conclave that is usually characteristic of A.I.M.E. Vincent Malcolm of Chapman Valve and Howard Boyer of American Bosch were the chief perpetrators of this skullduggery, which included plant trips, several down-to-earth new-development papers, a high-temperature materials symposium, and a social hour. . . .

Among the relevant and not-so-relevant items picked up especially for your edification were these:

Malcolm believes many of our present "super-alloys" are much too complicated, and thinks the old dependable 35-16 nickel-chromium-iron casting alloy doped up with a little vanadium would be a good simple answer for a lot of high-temperature problems; he's used it successfully for valves operating at 1800 F. . . .

Practically everybody agreed that the factors chiefly responsible for the non-uniformity of many super-alloy products can be grouped under the head of "processing variables" and that only when we learn how to control with nearly infinite precision every melting, molding, casting, heat treating (including loading), cooling, rolling, forging, joining, finishing, etc. operation, can we achieve a reasonable approach to uniform service behavior. A few processors have evidently done this—many have not. . . .

Springfield's mayor, an engaging gentleman named Brunton, neither smokes nor drinks. As a lifetime of preparation for an evening with a bunch of engineers, this was wisdom beyond words.

A new twist in metal-processing is the twist-bonding method of bonding solid aluminum to heavy-bodied stainless steel, developed and described by V. W. Cooke of Pratt & Whitney Aircraft Division. . . .

Slur-of-the-month prize goes to the Sheraton Hotel chain for their sign in the hotel lobby reading, in large type, "AVOID WORCESTER" followed in small type by "during the week of May 8th" (because of a scheduled convention at their Worcester hotel). A fine way to treat the heart of the Commonwealth, say we.